The Engineer

APRIL 10, 1953 — 28, ESSEX ST., STRAND, LONDON, W.C.2 — TWO SHILLINGS

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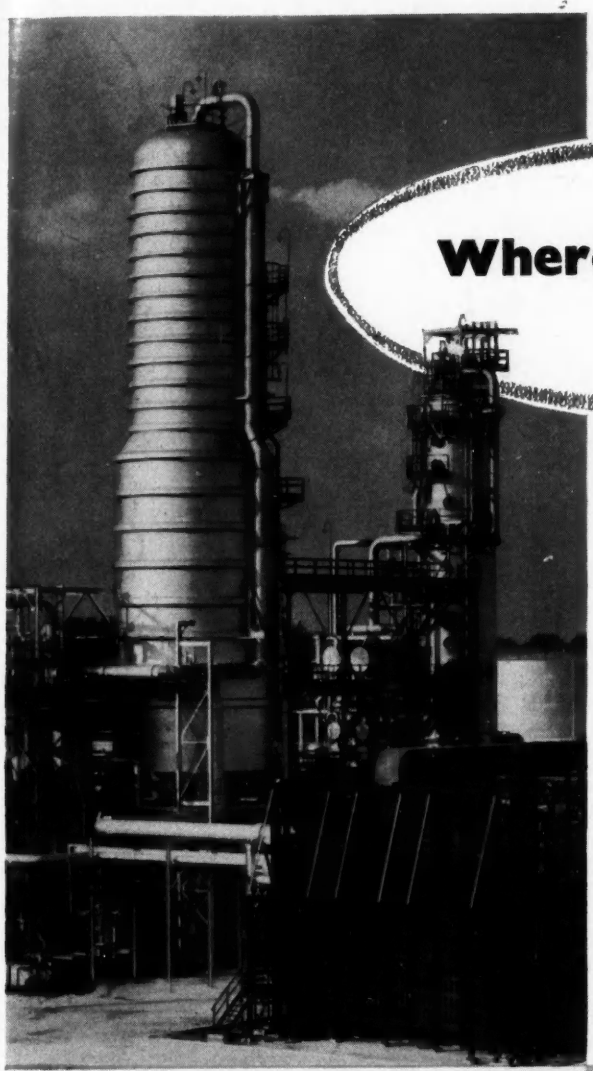

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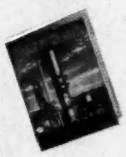
Fitting Monel tubing and bubble cap trays. (By courtesy of Messrs. Foster Wheeler Ltd.)

One of the distillation units at the Fawley Refinery. (By courtesy of the Esso Petroleum Co. Ltd.)

OUR TECHNICAL PUBLICATIONS



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MONEL* and Some Other High-Nickel Alloys *versus* SULPHURIC ACID — a 72-page technical publication, containing a wealth of data based on research and plant corrosion tests.

* *Monel is a registered trade mark.*

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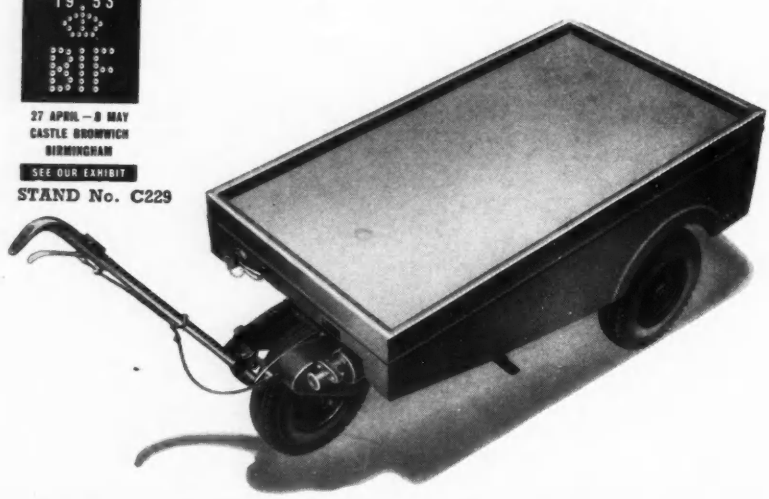

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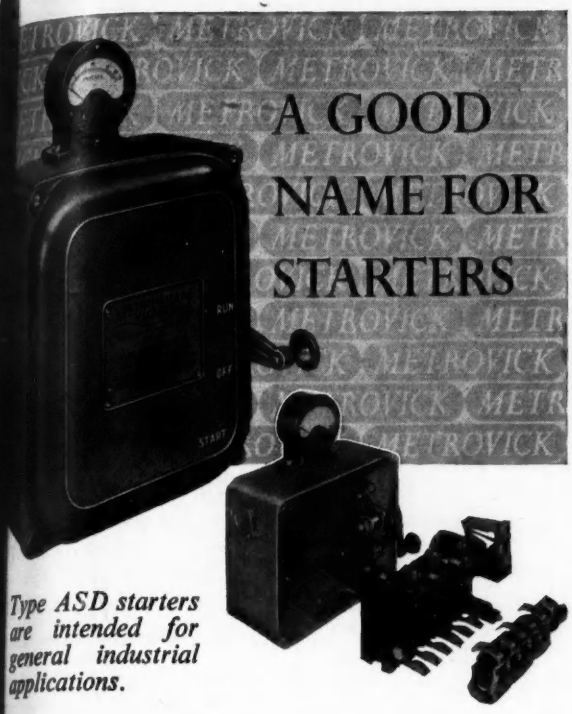

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THE ENGINEER

ESTABLISHED 1856

Vol. 195 No. 5072

APRIL 10, 1953

28 Essex Street, Strand, London, W.C.2

Telephone : CENtral 6565 Telegrams : Engineer Newspaper, Estrand, London

Published every Friday Registered as a Newspaper

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NOTICE TO READERS
All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

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PUBLIC APPOINTMENTS

ROYAL TECHNICAL COLLEGE, SALFORD

Principal: P. F. R. VENABLES, Ph.D., B.Sc., F.R.I.C.

MECHANICAL ENGINEERING DEPARTMENT

GRADE B ASSISTANT

Applications are invited for the post of Grade B ASSISTANT in the Mechanical Engineering Department. Applicants should hold a Degree and/or professional qualifications and should have had industrial experience, including drawing-office work. The successful candidate will be required to take Engineering Drawing up to Part I, B.Sc. (Eng.), standard, and general subjects to O.N.C. standard.

The salary for the above post will be in accordance with the Burnham Technical Scale, 1951, for Assistants Grade B, that is £490 by £25 to £765, plus graduate and training allowances.

Forms of application and further particulars may be obtained from the Principal, to whom forms should be returned within 14 days from the appearance of this advertisement.

H. H. TOMSON,
Clerk to the Governors.

E8143

THE COLLEGE OF AERONAUTICS

PERRING SCHOLARSHIP IN AERONAUTICS

Applications are invited for the PERRING SCHOLARSHIP IN AERONAUTICS, valued £400 per annum, tenable at the College of Aeronautics. The successful candidate will be admitted to the two-year course at the College.

Applicants should preferably be Honours Graduates or Final Year Undergraduates in Engineering, Mathematics or Physics; applications from non-graduates with comparable qualifications will also be considered. Candidates must be British subjects domiciled in the United Kingdom.

Forms of application and statement of conditions will be forwarded on written application to The Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks.

The closing date for the receipt of applications is 1st June, 1953. E8124

THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION

PLANT ENGINEERING DIVISION

MECHANICAL ENGINEER

MECHANICAL ENGINEER required by the above Association for the post of Head of the Mechanical Engineering Section of the Plant Engineering Division. Duties comprise leading a small team of mechanical engineers engaged in research on plant used in iron and steel works, encouraging the application of the results of the research in the works and seeking and assessing new problems for investigation. Previous experience in the iron and steel industry is not essential provided the applicant has a wide knowledge of mechanical engineering and a good grasp of fundamentals. Honours Degree in Mechanical Engineering essential. Starting salary within the range £1000 by £40 to £1400, according to age, qualifications and experience. Post is superannuated under the F.S.S.U. Location of work London.—Written applications only to Personnel Officer, B.I.S.R.A., 11, Park Lane, London, W.1. E8112

BRITISH ELECTRICITY AUTHORITY

SPECIFICATIONS AND CONTRACTS BRANCH

ELECTRICAL ENGINEER (CONTRACTS)

British Electricity Authority, Specifications and Contracts Branch, Generation Construction Sub-Department at Headquarters, London, require an ELECTRICAL ENGINEER (CONTRACTS). Salary not less than £1500 inclusive. Candidates must be Corporate Members of the I.E.E. and have wide experience in connection with contracts for electrical plant and equipment for large modern power stations. Duties include critical examination of tenders and specifications for electrical plant, preparation of recommendations for placing of contracts, negotiations with contractors, settlement of claims and attendance at meetings of technical and other committees associated with this type of plant.

Applications, stating age, present salary and full details of qualifications and experience, to D. Moffat, Director of Establishments, Winsley Street, London, W.1, by 27th April, 1953. Quote Reference E/359. E8098

MINISTRY OF SUPPLY

DIVISION OF ATOMIC ENERGY (PRODUCTION)

LEADING DRAUGHTSMEN

LEADING DRAUGHTSMEN required by Division of Atomic Energy (Production) to lead teams of draughtsmen engaged on mechanical and chemical plant design and layout. Qualifications: recognised engineering apprenticeship and H.N.C. Good drawing-office experience on mechanical or chemical plant essential. Candidates must have keen interest in undertaking new kinds of work. Salary: £592–£702.—Applications to Ministry of Supply, D.At.En. (P.), Risley, Warrington, quoting 445. E8093

PUBLIC APPOINTMENTS

NATIONAL COAL BOARD

PRODUCTION DEPARTMENT

SENIOR DESIGNER DRAUGHTSMAN AND ENGINEERING DRAUGHTSMAN

National Coal Board invite applications for the undermentioned superannuable appointments in the Production Department at London Headquarters.

SENIOR DESIGNER DRAUGHTSMAN, salary range £610 to £860 per annum, plus London location allowance, according to qualifications and experience. Candidates should have first-class experience in the design of winding engines and equipment and layout of colliery plant. They should be in possession of at least Higher National Certificate or equivalent (Ref. No. TT/617).

ENGINEERING DRAUGHTSMAN salary range £503 to £610 per annum, plus London location allowance, according to qualifications and experience. Candidates should have experience in layout work and general mechanical engineering; knowledge of power generation equipment would be an advantage (Ref. No. TT/618).

Write, giving full particulars (in chronological order) of age, education qualifications and experience (with dates), to National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, marking envelope with the relevant TT reference number quoted above. Closing date 15th April, 1953. Original testimonials should not be forwarded. E8071

CROWN AGENTS FOR THE COLONIES

LONDON OFFICE

LEADING DRAUGHTSMAN

LEADING DRAUGHTSMAN required for the London Office. Salary: £570 by £20 to £670 by £5 to £675 a year. Pay addition to basic salary payable at the rate of 10 per cent on first £500 and 5 per cent on remainder. Extra duty allowance of 8 per cent on annual basic salary plus pay addition also payable at present. Engagement will be on unestablished terms, terminable by one month's notice from either side, with the prospect, after satisfactory service, of appointment to the established and pensionable staff, vacancies permitting, and promotion to more senior grades if suitably qualified. The normal working week is 45½ hours and extra duty allowance is paid for hours worked in excess of 42.

Qualifications: Candidates should have been apprentices in carriage and wagon building at one of the works of British Railways or of a contractor. They should have had experience in designing detail parts of carriages and wagons and must be good draughtsmen. A knowledge of locomotive construction would be an advantage. Apply at once by letter, stating age, full names in block letters, and full particulars of qualifications and experience, and mentioning this paper, to the Crown Agents for the Colonies, 4, Millbank, London, S.W.1, quoting on letter M.29909.B. The Crown Agents cannot undertake to acknowledge all applications and will communicate only with applicants selected for further consideration. E8141

WALES GAS BOARD

HEADQUARTERS' STAFF

MECHANICAL ENGINEER

Applications are invited for the position of MECHANICAL ENGINEER on the Headquarters' Staff of the Wales Gas Board.

Duties will include the design and costing of schemes for the economical application of all customary forms of power, including steam, electricity and internal combustion engines, and the preparation of estimates for, and supervision of, the work of installing, dismantling and repairing gas works' plant throughout the Board's area, which is carried out by a staff of some thirty mechanical fitters and erectors under the mechanical engineer's control

The work covers all types of gas works' plant, but practical experience in the construction and repair of gasholders will be a desirable qualification.

The commencing salary will be in the region of £900 per annum, in accordance with qualifications and experience.

The successful candidate will be required to pass a medical examination and to join the Board's superannuation scheme.

Applications, stating age, qualifications and experience, accompanied by the names of two referees, should reach the undersigned not later than the 25th April, 1953.

C. B. MAWER,
Secretary.

Wales Gas Board,
1 and 2, Windsor Place,
Cardiff. E8130

THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION

PLANT ENGINEERING DIVISION

TECHNICAL ASSISTANTS

TECHNICAL ASSISTANTS required by the Civil and Structural Section of the Plant Engineering Division to assist in a variety of applied research projects in the Iron and Steel Industry. Candidates should have, or be studying for, a National or Higher National Certificate and should be capable of assisting either in structural calculations or in the use of electrical strain gauge equipment. Time off for study for a further qualification may be given. Previous experience in research work is desirable but not essential. Age 22–26. Starting salary according to age, qualifications and experience, within the range £450–£580 p.a. Location of work is London with site visits. Staff pension scheme.—Written applications only to Personnel Officer, B.I.S.R.A., 11, Park Lane, London, W.1. E8113

PUBLIC APPOINTMENTS

GOLD COAST LOCAL CIVIL SERVICE

PUBLIC WORKS DEPARTMENT

CHIEF MECHANICAL ENGINEER
GOLD COAST (CDE.112/13/08)

A vacancy exists for a CHIEF MECHANICAL ENGINEER in the Public Works Department of the Gold Coast Local Civil Service. Duties are to organise, administer and be responsible for the mechanical engineering branch and activities of the Public Works Department and to train and administer the staff of the Mechanical Engineering branch. Appointment is on contract in the salary scale £2190–£2310 per annum, with a gratuity of £37 10s. for each 3 months' satisfactory service.

Free first-class passages are provided for the officer, his wife and up to 3 children under the age of thirteen. Government quarters, if available, are provided at a rental of £120 per annum. Leave is granted at the rate of 7 days for each completed month of resident service after a tour of 18–24 months.

Candidates, preferably under 45 years of age, must be A.M.I.M.E., with at least 10 years' public works experience since passing or gaining exemption from Sections A and B of the Institution's Examination, including 5 years in a responsible position comparable to that now advertised. Recent experience in a similar capacity in a public works department or large construction organisation an advantage.

Apply in writing to the Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, giving briefly age, qualifications and experience. Mention the reference number (CDE.112/13/08). E8142

CITY OF CHICHESTER

(i) ASSISTANT WATER ENGINEER
(ii) WATERWORKS PUMPING SUPERINTENDENT

Applications are invited for the above appointments.

Candidates for (i) must be Chartered Civil Engineers with previous waterworks experience. Salary: £625–£685 (A.P.T. VA), and car allowance.

Candidates for (ii) must have experience in the maintenance of large-scale pumping machinery (oil and electric). Salary: £480–£540 (Misc. V), and free house. The Pumping Superintendent will not be required to take up his duties before the Autumn.

Further particulars may be obtained from the Water Engineer and Manager at the address below.

ERIC BANKS,
Town Clerk.

Greyfriars,
North Street,
Chichester.
1st April, 1953. E8156

MINISTRY OF SUPPLY

DIVISION OF ATOMIC ENERGY (PRODUCTION)

LEADING DRAUGHTSMEN (ELECTRICAL)

LEADING DRAUGHTSMEN (ELECTRICAL) required by Division of Atomic Energy (Production) to lead teams of draughtsmen engaged on layout work of electrical equipment for substations and chemical plant process buildings, main cabling, and all types of lighting and power installations. Qualifications: recognised apprenticeship and H.N.C. Good drawing-office experience on types of work mentioned essential. Salary: £592–£702.—Applications to Ministry of Supply, D.At.En. (P.), Risley, Warrington, quoting 446. E8092

NORTH WESTERN GAS BOARD

LIVERPOOL GROUP

DRAUGHTSMEN, LIVERPOOL

Applications are invited from qualified DRAUGHTSMEN for the above pensionable appointments at salaries within Grade A.P.T. 7 (£545–£625 per annum), A.P.T. 8 (£585–£665 per annum), and A.P.T. 9 (£615–£715 per annum), according to qualifications and experience.

Applicants should have experience in the design and detailing of gas or chemical by-product plant.

Application should be made on the official form, obtainable from the Chief Personnel Officer, North Western Gas Board (Liverpool Group), Radiant House, Bold Street, Liverpool, 1, and should be returned within 14 days. E8110

BRITISH ELECTRICITY AUTHORITY

EASTERN DIVISION

SENIOR DRAUGHTSMEN (STRUCTURAL)

Applications are invited for the following positions in the Generation (Construction) Department at Divisional Headquarters:—SENIOR DRAUGHTSMEN (STRUCTURAL).

The commencing salaries (which include London weighting) will depend upon experience and qualifications, but will be within the following range:—

Grades 5–4, £595–£819 per annum.

Applicants should be capable of preparing working drawings associated with the design of structures in connection with generating stations covering structural steelwork and reinforced concrete.

Applications, stating age, qualifications and experience, should be sent to the Divisional Controller, British Electricity Authority, Eastern Division, Northmet House, Southgate, N.14, by 25th April, 1953.

W. N. C. CLINCH,
Controller.

E8086

PUBLIC APPOINTMENTS

LEAVESDEN HOSPITA

ENGINEER-IN-CHARGE (RESI

ENGINEER-IN-CHARGE (Resident) at Leavesden Hospital for Mental Defectives, Langley, Watford, Herts. Salary, £550 to £650 per annum. Rent of house, 25s. 6d. Should possess Higher National Certificate or equivalent. Hospital experience an advantage.

Applications giving full details of age, ... ship, experience and qualifications, to ... names of two referees, to the Group ... Leavesden Hospital, not later than ... 1953.

BRITISH ELECTRICITY AUTH

ASSISTANT COMMERCIAL MA

British Electricity Authority require ... TANT COMMERCIAL MANAGER ... quarters in London. Candidates should ... responsible positions and have wide exp... the commercial, technical and economic ... electricity supply. Salary according to ... and experience within provisional sala... £1575–£2000, inclusive.

Applications, stating age, qualifications, ... and present salary, to D. Moffat, Director ... lishments, Winsley Street, London, W.1, ... April, 1953. Quote Reference E/363.

TOTTENHAM GROUP HOS... MANAGEMENT COMMITT...

THE GREEN, N.15

ST. ANN'S GENERAL HOSPIT...

ASSISTANT ENGINEER

ASSISTANT ENGINEER (Non-resident) ... at St. Ann's General Hospital, N.15, with ... National Certificate in Mechanical Engin... equivalent qualification. Whitley Council ... of service. Salary: £400 by £15 to £475 p... plus £30 London Weighting. Applicat... from Secretary, to be returned by 18th Apri...

TENDERS

INDIA STORE DEPARTME...

MACHINERY

The Director-General, India Store De... 32/44, Edgware Road, London, W.2, ... TENDERS for the SUPPLY of MACHI... listed below:

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D.O. 2391/52	Mechanical Stokers, chain grate type, for three Lancashire boilers, complete with forced draught fans .. ..
D.O. 2408/52	Heavy-duty steam Locomotive Shunting Crane, complete; gauge 5ft. 6in., capable of lifting 10 tons at a radius of 25ft. approx. .. ..
H.N. 4100/52	Capstan Lathes (Herbert No. 4, or similar) ..

Forms of Tender, which are returnable by 22nd May, 1953, may be purchased at the address at a cost of 10s. in respect of each reference number.

The appropriate reference(s) must be quo... applications.

INDIA STORE DEPARTME...

TECHNICAL CO-OPERATION ADMINISTRATION PROGRAM...

In connection with the PROCUREME... STEEL for requirements in India under the T... Co-operation Administration Programme, ... Supply Mission, Washington, D.C., U.S.A., ... TENDERS for the SUPPLY of 5825 long ... BLACK SHEETS in 10 gauge and 4500 ... in 16 gauge, both in various sizes in accordan... the details and other particulars as descr... Schedule Parts 1 and 2 of Tender No. B2/15... copy of which can be obtained from address li... below. Delivery required is from June to ... 1953. Completed Tenders should be returne... India Supply Mission, Washington, not la... 11 a.m. Est. on 4th May, 1953.

Please apply for the prescribed Tender fo... Director General, India Store Department, ... 32/44, Edgware Road, London, W.2, ... Reference S.6817/52.

COMMISSIONERS OF PUBL... WORKS

GENERATING PLANTS

Sealed TENDERS addressed to the Se... will be received up to, but not later than 12 ... noon, on the 30th April, 1953, for the SUPPL... DELIVERY f.o.q. Dublin, of TWO DI... DRIVEN A.C. GENERATING PLANT ... accordance with specification and condit... contract exhibited at this office.

Applications for a copy of the specification ... be addressed to this office.

The Commissioners will not be bound to acc... lowest or any Tender.

J. TYRRELL,
Secret...

Office of Public Works,
Dublin,
1st April, 1953. E...

THE ENGINEER

APRIL 10, 1953

The Coastal Flooding Bill

THE Coastal Flooding (Emergency Provisions) Bill was given a second reading in the House of Commons on Wednesday of last week. Moving the second reading resolution, the Minister of Agriculture and Fisheries, Sir Thomas Dugdale, said that the Bill was an emergency and largely temporary measure designed to effect quickly permanent repairs to the country's sea defences. The first part of the Bill dealt with the restoration of those defences and the second part with the rehabilitation of agricultural land which had been flooded all along the East Coast. The Minister went on to say that the operation of closing the breaches had been tackled with great energy, and the task of strengthening the temporary work had gone ahead in the same way. Along the 1000 miles of coastline for which the East Coast river boards were responsible; however, the sea defences had been generally weakened and were in no fit state to stand up to the storms and tidal conditions that the winter months almost invariably brought to our coasts. The sea defences must be restored by permanent works at least to their pre-flood strength, and the full cost of such work carried out by the river boards for that purpose before the end of September would be met by the Government. After referring to the work of the Waverley Committee, the Minister said that, without waiting for that committee's report, more extensive work would have to be done before next winter for the protection of certain populated areas such as Canvey Island and some important industrial establishments such as the oil plants on the Thames estuary. Some part of the cost of those additional works could properly be met from local resources. Such a local contribution might be met either by a larger precept upon the internal drainage board, towards the funds of which the owners of the big plant would be a major contributor as one of the largest ratepayers, or, alternatively, in appropriate cases, the owners of the plant would be asked to pay direct part of the cost. The responsibility for doing the work necessary to protect low-lying coastal areas rested with the river boards. Local negotiations as to the financing of the additional works, the Minister stated, would not be allowed to delay their execution.

The Royal Aeronautical Society

IT has been announced by the Royal Aeronautical Society that Sir William Scott Farren has been elected president for the year 1953–54, and will take office at the annual general meeting on May 7th. Sir William was born at Cambridge on April 3, 1892, and was educated at Perse School and Trinity College, Cambridge. When only twenty-two years of age he joined the Royal Aircraft Factory at Farnborough upon the suggestion of Professor Bertram Hopkinson. The following year he took charge of the experimental and design aspects of aerodynamics there during what was perhaps one of the most fascinating periods in the development of flight. At the end of the first world war he was awarded an M.B.E. and left Farnborough only to return again in July, 1941, as Director of the Royal Aircraft Establishment. He received whilst there his C.B. in 1943, and was elected F.R.S. in 1945. In the intervening years Sir William had largely lent himself to academic work, and in 1920, when University Lecturer in Engineering and later in Aeronautics at Cambridge, he took part with Sir Melville Jones in many aeronautical researches. In 1937, however, he abandoned academic work, and until his return to Farnborough he assumed a number of Government research directorships. Since the last war Sir William has been principally engaged with the delta projects of A. V. Roe and Co., Ltd., where he is the technical director. Sir William is one of the few pilots who, starting on the Farman "Longhorn" and "Shorthorn" aircraft in 1916, has since flown most British and American aircraft of the last war, and some German machines. Sir William was created a Knight Bachelor last year.

Cardiff Shipowners' Annual Meeting

THE Cardiff and Bristol Channel Incorporated Shipowners' Association held its annual meeting on Tuesday of last week, at which Mr. A. J. Jenkins was elected chairman. In the course of his address, Mr. Jenkins commented on the reduction in the volume of trade and the difficulties in finding employment for ships and was pleased to note a reduction in the cost of coal bunkers, together with a recession in the price of oil. The relaxation in certain Government controls and the easing of Australian import restrictions was encouraging, and Mr. Jenkins thought that proposed coal exports to the Argentine would help towards re-establishing the former combination of coal and grain cargoes. Continuing, the chairman said that the shortage of steel supplies to shipbuilders and the resulting delay in delivery of the ships, plus other factors, had greatly increased the costs against the shipowners. External economic conditions had improved recently, but Mr. Jenkins felt that internal conditions were not quite so satisfactory, and with regard to shipping the deadload of taxation prevented the provision of adequate resources for ship replacement programmes. He wondered if the nation appreciated the position of tramp shipbuilding and the fact that practically one-third of the fleet would have to be replaced within ten years. The situation, the chairman maintained, called for special consideration, especially when the significance of the large contribution by shipping to the balance of payments was realised. The restoration of the 40 per cent initial allowance would help and Mr. Jenkins suggested an incentive scheme to encourage shipowners to build. This scheme broadly provides for the setting aside of a proportion of the taxes, paid by shipowners into a special account, the use of which would be restricted to the provision of funds for the building of new tonnage.

R.E.M.E. Memorial Fund

LAST August an appeal was launched among past and present members of the Corps of Royal Electrical and Mechanical Engineers to raise a fund to commemorate those who lost their lives in the second world war whilst serving with R.E.M.E. It is realised that many who might wish to contribute cannot be reached individually, and a general announcement about the appeal has therefore been made. This announcement says that, although the R.E.M.E. only came into being as a separate Corps less than three years before the end of the war, no fewer than 1481 of its members in all ranks laid down their lives. The preparation of a Book of Remembrance, in which will be inscribed the names of all those who died, has been adopted as the first claim on the fund. As a further and major measure, the general concensus of opinion is in favour of some form of endowment scheme for the benefit of those who are serving or have served in the Corps, and their families. According to funds eventually available, this scheme would include such measures as assistance to convalescent patients, aid to those of advancing years, and educational grants in amplification of State schemes. It is hoped that the aggregate of subscriptions from all sources will establish a memorial worthy of those whom it is wished to commemorate, and of the Corps which represents mechanical and electrical engineering in the Army. Subscriptions may be sent to R.E.M.E. Memorial Fund, Midland Bank, Ltd., Wokingham, Berkshire.

I.Mech.E. Coronation Week Arrangements

THE Institution of Mechanical Engineers has made certain arrangements for the convenience of members and their ladies who will be in London during the first week of June for the celebrations of the Coronation of the Institution's Patron, Queen Elizabeth II. As Coronation Day, June 2nd, is a public holiday, the Institution headquarters at Storey's Gate, St. James's Park, will be closed during normal office hours, but will be open from 4.30 p.m. to 9.30 p.m. to enable any members and their ladies to obtain light refreshments at a small charge. The same facilities will be available from 5.30 p.m. to 9.30 p.m. on Wednesday and Thursday, June 3rd and 4th. In order to assess the catering requirements, members who expect to take advantage of these facilities are asked to inform the Institution beforehand. On Friday, June 5th, there is to be a Coronation Conversazione and Dance at the Institution headquarters at Storey's Gate. Members and guests will be received by the president, Mr. A. Roebuck, and Mrs. Roebuck, from 8 to 8.30 p.m.; a dance is being arranged to take place in the library, and there will be a continuous showing of cinematograph films of general interest in the main hall. Buffet refreshments will be served during the evening. The price of tickets for the conversazione will be 15s. single and 30s. double.

The British Association

THE British Association for the Advancement of Science has issued this week the preliminary programme of its 115th annual meeting, which is to be held in Liverpool from September 2nd to 9th, under the presidency of Sir Edward Appleton, F.R.S. The inaugural session is to take place on Wednesday evening, September 2nd, in the Philharmonic Hall, when Sir Edward Appleton will deliver his presidential address on "Science for its Own Sake." On the following evening, Sir Edward is to give a presidential address to student members of the Association, the title of which is "Finding Things Out with Radio and Rockets." Other evening discourses during the week of the meeting are to be delivered by Sir Harold Spencer Jones, F.R.S., on "Continuous Creation," and by Mr. Eric Shipton on "Everest." A full programme is being arranged for each of the Association's thirteen sections. This year's president of Section G, Engineering, is Lord Dudley Gordon, who will deliver his address on Thursday, September 3rd. The meetings of Section G are to be held in the Walker Engineering Laboratories of the University. Five previous meetings of the British Association have been held in Liverpool, the last being in 1923 under the presidency of Sir Ernest Rutherford. It is particularly appropriate that this year in which the Association visits Liverpool again is the year in which the University of Liverpool celebrates its jubilee.

Water Power in the Italian Alps

No. IX—(*Concluded from page 485, April 3rd*)

This series is brought to a conclusion with a description of the hydro-electric schemes of the Societa Idroelettrica Piemonte in the western area. The developments on the Ticino below Lake Maggiore provide examples of low head power stations and are situated in a region of considerable interest to the hydraulic engineer. By contrast, a large high head scheme under construction close to the French border at Valgrisanche is also described.

ANOTHER large group of companies concerned with the generation and distribution of power is the Societa Idroelettrica Piemonte, which, either directly or indirectly, generates about 3000 million kWh annually from an effective power installation of 800MW. The "S.I.P." has a controlling interest in many electrical companies of various kinds, including the Radio Audizioni Italia, which holds exclusive rights for broadcasting in Italy. As regards the generation of power, however, there are three companies in the group which need be mentioned here. The S.I.P. Company itself, apart from participating in the Sarca-Molveno development described earlier, is responsible for hydro-electric exploitation in north-western Piedmont, in the catchments of the Rivers Dora Baltea, Stura, Dora Riparia and on the Po itself, near Turin. It also owns the Cardano power station on the Isarco in the upper Adige valley near Bolzano, which was described in some detail in THE ENGINEER of March 29 and April 5, 1935, when it had recently been completed. At that time it was the most powerful hydro-electric development in Europe, having an installed capacity of about 205MW in eight sets; it generates about 500 million kWh of power annually. The second company of the group, the Societa Piemonte Centrale di Elettricita, also generates power from hydro-electric schemes in Piedmont, generally in the area south of that of the S.I.P. itself, whilst the third concern, "Vizzola" Societa per Azioni Lombarda per Distribuzione di Energia Elettrica, distributes power in the neighbourhood of Milan and has hydro-electric power stations on the Ticino river and in the Valtellina (on a northern tributary of the Adda, on the other side of the main stream from the Falck Company's area) and the upper Brembo Valley, another mountain stream whose catchment lies south of the Valtellina.

The works of the last-named company in the Valtellina and Brembo Valley are generally similar in character, though smaller in size, to many of the mountain schemes already described. However, the works on the Ticino river are low-head schemes which are not without interest from both the historical and technical points of view. There are at present three principal power stations on the Ticino river below its outlet from Lake Maggiore. The lake forms a natural storage reservoir which is of importance for the irrigation of the plains further downstream. Its capacity has been considerably increased by the construction of the Miorina barrage, which, by raising the water level at this point by 1·5m, has provided 315 million cubic metres of extra storage, the area of Lake Maggiore being 210 square kilometres. This extra storage has permitted the normal summer flow to be increased by 80 cumecs, so that apart from its beneficial effect in controlling the flow through the network of irrigation canals, the barrage has permitted an increase in the area of land irrigated and has enabled an extra 30 million kWh to be generated at the power stations.

The barrage is shown in Fig. 55, from which it may be observed that it consists of four bays each closed by twenty-five sluice gates, which are operated by the two transporters which travel along the steel bridge above. Each gate is pivoted at the bottom and is supported in its upright position by a strut which is hinged to it and forms a prop. The strut has a shoe at its bottom end which engages in a tooth on the sill of the barrage. To lower the gate it is pulled forward by the hook on the end of the transporter's arm so that the strut disengages and slides down a path in the sill until the gate is flat. A full description of an installation of this sort, at Seyssel, on the River Rhone, was given in our issue of December 15, 1950. The narrow width of the gates ensures that the hydrostatic load on each one of them is transmitted directly to the sill of the barrage. In this case the gates are 3m in height, so that although the normal lake level has been increased by 1·5m, control over a range of 3m is ensured; in fact, the natural variations in the lake level were greater than this amount so that there has been no adverse effect on its scenic amenities due to its use as a storage reservoir.

Downstream of the Miorina barrage, a combined barrage and low-head power station is now under construction at Porto della Torre, and will be finished, it is estimated, in 1954. The completed developments start a little further downstream, where there is a weir across the river with an intake structure at the left bank from which the diversion to Vizzola power station commences. These two structures, which are shown in Fig. 54, were built in 1884 by Cipolletti, to divert water into the Villoresi canal for irrigation. The weir across the Ticino is 290m in length, and, we are informed, is remarkable for the fact that it was designed to create a standing wave at its toe to help dissipate the energy of the discharge flowing over it. At times this flow is heavy and the upstream level may be 4·5m above the crest of the weir with a flow of some 5000 cumecs. Since it has been in service, the weir has required only moderate amounts of maintenance work, mainly to keep the rip-rap protection at the toe in good order, which must be done annually. The sluice gates of the intake barrage are operated manually from the headstocks which may be seen under the arches in our illustration; this structure also is in a good state of preservation. There is a lock on the right-hand side of the illustration.

Construction of the first Vizzola power station was completed in 1897, utilising the intake works which we have just described. It was opened in 1901 by King Victor Emmanuel III and was for many years the most ambitious hydro-electric development in the country (see the article on "Italian Industries," to which we have referred previously, THE ENGINEER, April 20, 1906). There were ten turbines installed, each of 2000 h.p., in a machine hall 45m long, and operating under a head of 22m.

Turbigo power station was completed not long after Vizzola in 1904, on the same general lines, but with a smaller head. It is situated on the banks of the ancient Naviglio Grande, and as originally constructed utilised a flow of 61 cumecs and a head of 8·7m. It was described in THE ENGINEER of December 23, 1904.

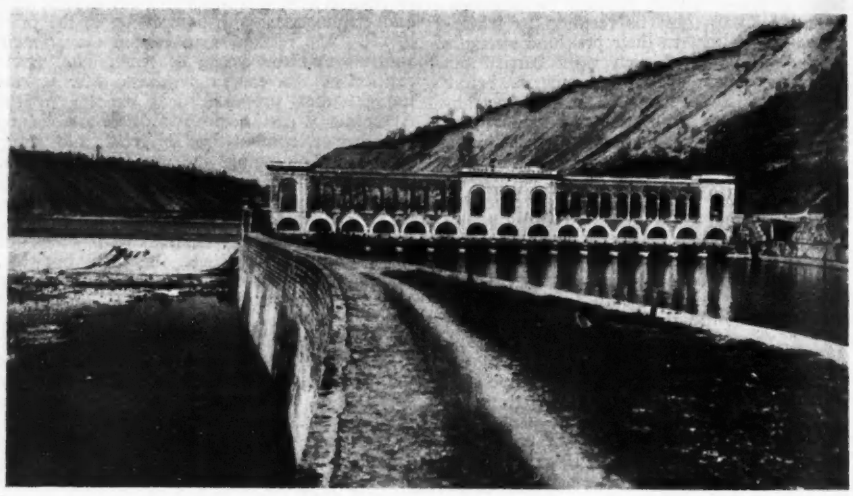


Fig. 54—Panperduto Weir and Intake

Reconstruction of these power stations on the Ticino was under consideration prior to the war, and at the end of 1939, Vizzola power station was shut down after having generated 3800 million kWh. As the power station now exists, the head has been increased, by carrying the last part of the canal on a substantial reinforced concrete structure, to 30·13m, and the flow to 124 cumecs. The installed capacity is now 32MW, with three vertical Francis turbine sets, each supplied by a short steel penstock leading from the end of the canal structure, and the power station is on a new site, close to the old one. Its annual production of power is now double the previous value. The head race canal of the old scheme runs beside that of the new and is utilised as a spillway. The transformer and switching station are inside a second building, erected on the substructure of the old power station.

Below Vizzola power station, the diversion canal, most of which is on made ground and is lined with concrete, continues to Torna-

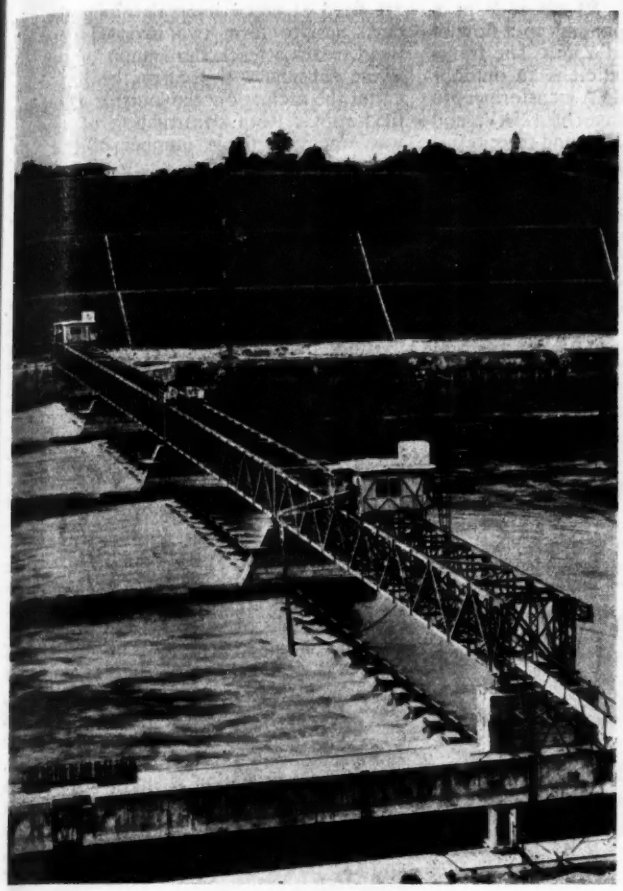


Fig. 55—Miorina Barrage

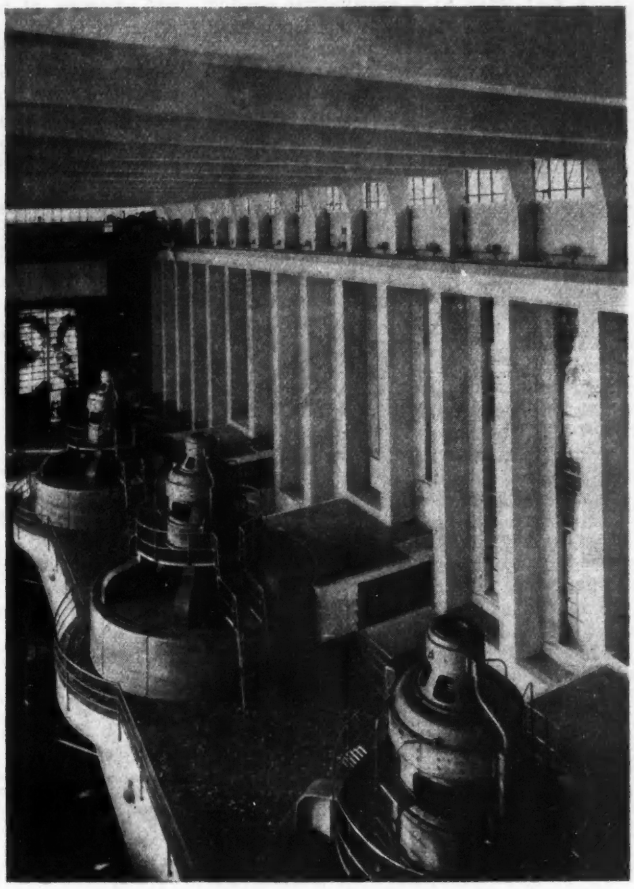


Fig. 56—Vizzola Power Station

vento power station. The construction of Tornavento and Turbigo power stations was undertaken successively after Vizzola had been rebuilt, Turbigo being completed in 1949. The small lower Turbigo station was completed in 1922. Details of the power stations are given in the table below.

Cimena Power Station

Another low-head power station of the S.I.P. group is the one at Cimena on the Po itself, just downstream of Turin. It was completed in 1949, with a total installed capacity of 22MW, in two similar vertical Kaplan turbo-alternator sets, a head of between 23·27m and 18·07m, and an annual output of some 134 million kWh, slightly more than half of which is generated in the winter.

There is a barrage across the River Po, 180m in length, with the intake of the diversion to the power station adjacent to it on the right bank. The barrage consists of a concrete weir 56m long, four openings, each of 25m and each closed by a sector gate, and an opening of 12·4m on the right bank, also closed by a sector gate. This last opening has a deeper invert than the others so that material rolled down by the river can be scoured through it and not diverted into the power station canal. The intake can be closed by sixteen sluice gates. The diversion canal and tunnel, with a total length of nearly 13km, carry a flow of 110 cumecs, with various bridges and similar works along the length of the canal.

The layout at the end of the tunnel may be observed from Fig. 57, which shows a cross section of the power station. Two reinforced concrete penstocks, 4·2m in diameter, each of which can be closed by an oil-servomotor-operated valve, lead down to the spiral casings of the turbines. As may be observed from the cross section, the bottom part of each penstock is of sheet steel. The spillway arrangements here are unusual; as may be seen from Fig. 57, the two side walls of the forebay form overflow weirs.

Power Stations on the Ticino

	Installed capacity, MW	Annual production, millions of kWh	Head, metres	Flow, cumecs	Turbines
Vizzola	32	220	30	124	Francis (three)
Tornavento...	7·5	50	7	124	Kaplan (one)
Turbigo	10	70	9·2	124	Kaplan (one)
Lower Turbigo	1	5	4·6	40	Francis (one)

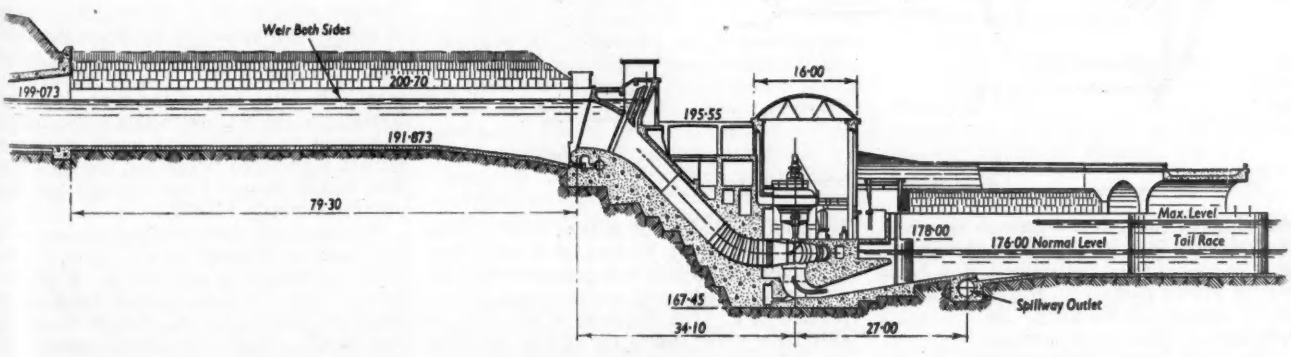


Fig. 57—Cimena Power Station

Each weir leads to a longitudinal conduit running underneath it, which continues down the slope beside the power station and is connected to the pipe shown under the tail-race in the cross section, so that each of the two spillway conduits is connected to one end of this pipe. Any flow which spills over the weirs is thus discharged across the width of the tail-race through the opening shown. This arrangement was arrived at after model tests, the spillway flow being ejected in this manner so that a proportion of its energy is dissipated and scouring is largely avoided in the tail-race.

The two turbo-alternator sets in the power station normally run at 214 r.p.m. and generate at 6·6kV, 50 c/s each at a power of 11MW, corresponding to a flow of 55 cumecs and a head of 25m. The transformer and switching station is an outdoor one, there being two 15MVA transformers to give a transmission voltage of 125kV, and two sets of busbars at 125kV and three transmission lines from the station at this voltage.

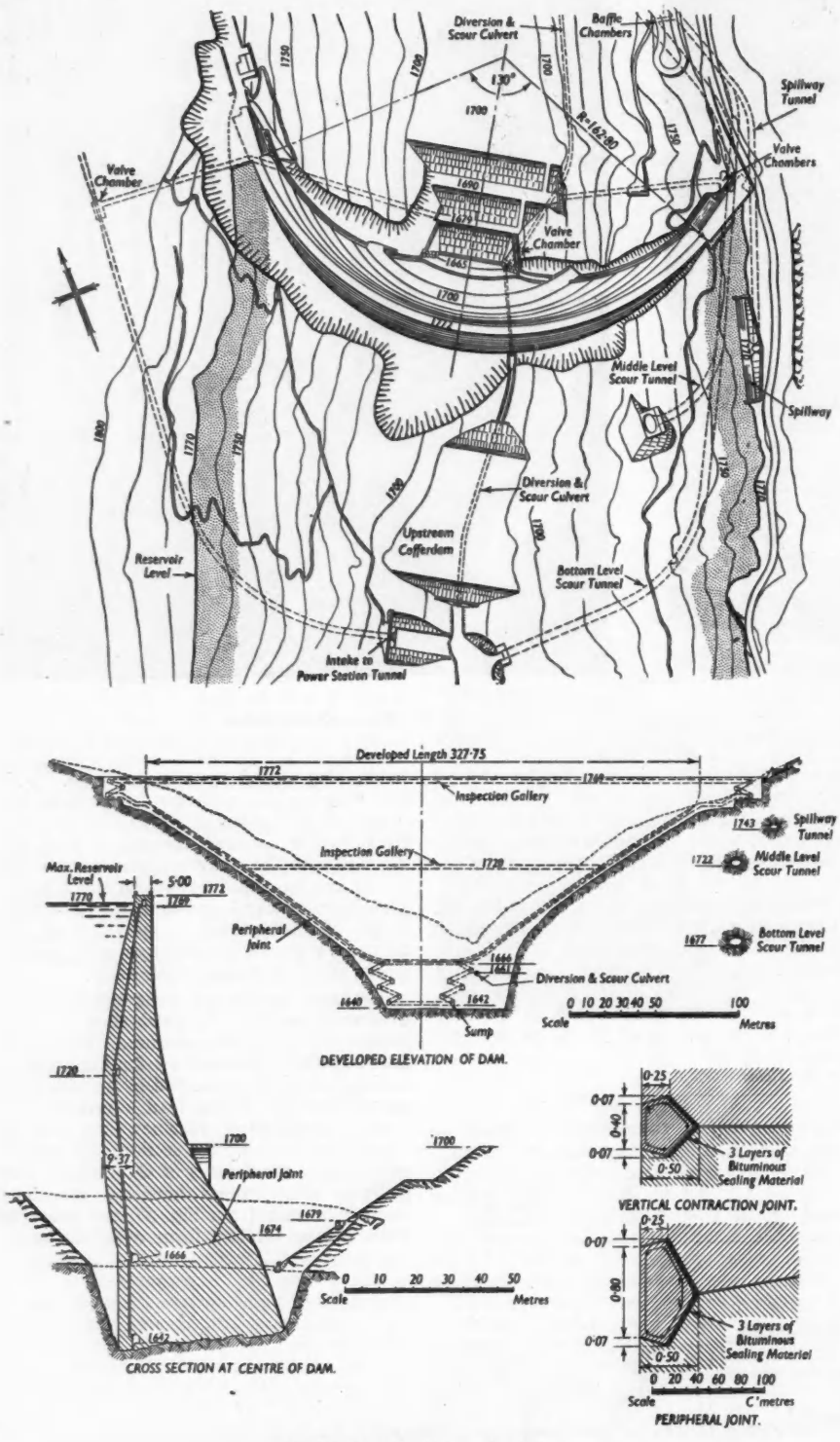


Fig. 58—Details of Beauregard Dam

The roof of the power station, which spans 15·3m, consists of an arch shell made up of hollow bricks joined together by cement mortar, with light steel reinforcement incorporated in it. The thickness of this shell is only 16cm ; the rise of the arch is just over 3m and it is tied across at the level of the springing at intervals. Four subsidiary ties are fixed at equal intervals along the principal ties, to form two inverted vees with their apexes at each third point of the arch. These subsidiary ties carry the flat ceiling under the arch ; on the outside there is a tiled roof. Roof construction of this sort was employed for a number of the S.I.P. group's power stations which were built at about this period, and makes an interesting comparison with present-day shell roof construction.

Some Alpine Developments

As mentioned earlier, the S.I.P. group has undertaken the hydro-electric development of several important Alpine streams to the north and west of Turin. Many of the power stations in this region have now been built for many years, and a considerable portion of some catchments is completely utilised. One major scheme is at present under construction on the Dora di Valgrisanche, a right-bank tributary of the Dora Baltea, near Aosta.

The Marmore torrent, another tributary of the Dora Baltea, which rises from various streams on the southern slopes of the Matterhorn, provides a good example of a series of power stations developing the total head available along its length. The reservoir of Goillet is at the head of the system. The dam, a gravity structure, is faced with masonry, as conditions are severe at this altitude (2526m) and the ground is free from snow for only a short time in the summer. Perreres power station is supplied from this reservoir, the head being 682m and the flow 3·3 cumecs. The two Pelton wheel sets in the power station generate at 50 c/s and 7kV, and the power is stepped up to 135kV for transmission.

A forebay for the diversion to Maen power station is formed by a small gravity dam across the Marmore just below the tail-race at Perreres. At the end of the diversion tunnel leading from this forebay there is a pumping station built on the mountainside at about the same level as Perreres power station. At times of low load water can be transferred by pumping against a head of about 350m from the Perreres tail-race pond to the Cignana reservoir, situated on a tributary, from whence a separate penstock descends to Maen power station. Thus the machines at Maen can operate under two heads (750m and 450m) ; of the three Pelton wheel sets installed, one operates under the small head and one under the larger, and the third, which consists of two Pelton wheels coupled on one side of the alternator, can use either head. Pondage is again provided in the tail-race, this time by a barrage across the Marmore. Various side-stream intakes, the largest from the Torgnon, increase the flow to the next power station at Covalou.

The intake to the last power station of the series, Chatillon, leads from the tail-race pond at Covalou, this power station discharging into the Dora Baltea. The group of power stations on the Marmore generates about 330 million kWh annually, of which about 140 million kWh is in the winter half-year. The total head of the group is almost 2000m, and the catchment area is 191 square kilometres ; 28·8 million cubic metres of storage is provided altogether, the maximum flow utilised being 12 cumecs, and the total installed capacity 125MW.

This series of power stations may be taken as typical of others of the S.I.P. group in the Alpine streams of Western Italy. There are, however, two underground power stations on the Dora Baltea which should be briefly mentioned. Both of them—Hone and Pontey—are of similar character, being run of river developments with intake bar-

rages on the Dora Baltea and diversion tunnels, in which the flow is at atmospheric pressure (part of the diversion to Pontey is in open channel) leading to a forebay excavated out of the rock, and thence with penstocks to the power station. Hone is noteworthy in that a single Kaplan turbine operates under the high head of 36·87m. It has been in operation since 1948 and was designed in 1940. This single set has a high degree of utilisation of about 6000 hours annually, which is equivalent to a load factor of the order of 70 per cent. Its installed capacity is 18·4MW and it generates about 120 million kWh annually (45 million during the winter). Pontey power station is a modern installation, the maximum flow diverted is the same as at Hone—55 cumecs—but the head is 69·5m. There are two vertical Francis turbo-alternator sets installed in it with a total capacity of 34·3MW and about 150 million kWh is generated annually.

The Valgrisanche Scheme

The Dora di Valgrisanche is being developed by the S.I.P. in the "classical" manner for a high-head scheme, consisting of a reservoir, diversion tunnel, sidestream intake, surge shaft, and underground penstocks and power station. However, the development exemplifies many points of modern practice, being on a larger scale than nearly all the group's schemes so far mentioned, and with a very substantial storage capacity in the reservoir, so that the proportion of summer to winter power will be the reverse of that prevailing for many earlier schemes, most of the power being generated in the winter, as is shown in the table herewith giving the principal data for the scheme.

The Valgrisanche Development

Installed capacity, MW	150
Production of power, kWh × 10^6:	
In winter	186
In summer	101
Annually	286
Head, metres:	
Maximum	1040
Mean	1010
Minimum	960
Flow, cumecs:	
Maximum	16·5
Mean	4·2
Reservoir capacity, cubic metres × 10^6	70
Catchment area above reservoir, sq km	93·6
Addition from sidestream intake, sq km	16·2

The catchment area is bounded on the west by the French frontier, with the Upper Isere draining the adjoining slopes on the French side. The altitude of the dam is 1770m (top water level) and the peaks at the watershed are generally above 3000m, the highest being the Grande Sassiere (3759m) at the south of the catchment. This peak is at the French border and is not far from Tignes dam.

Construction of the dam is at present in its early stages, and is expected to be completed by 1957, with the power station in operation without the reservoir by next winter. The valley is remote and not easily accessible, so that very extensive preliminary works have been necessary, including the construction of ropeways for the transport of cement to the dam site, and for supplying the adits of the diversion tunnel.

Beauregard dam will be an arch gravity structure with a total height of 426ft. It is shown in plan and cross section in Fig. 58. It may be observed that, as with the S.A.D.E.'s dams and in contrast to Forte Buso dam, mentioned last week, a symmetrical shape has been achieved inside the peripheral joint. In cross section the dam is similar to Forte Buso dam; however, its radius of curvature of 162·8m is as large as that of Pieve di Cadore dam, although in the latter case the height of the arch from the peripheral joint to the crest is, by contrast, only about 50m over the great majority of the length of the dam. The joint details in Fig. 58 may be noted (the peripheral joint for Lumiei dam was illustrated in Dr. Semenza's paper, referred to earlier).

The considerable volume of excavation necessary at the dam site has now been largely carried out; the bottom of the valley consists of a poor shale overlying mica schist. The shale is not strong enough to support the dam, and the "plug" shown in the lower parts of the cross section will be built where this deep excavation is necessary.

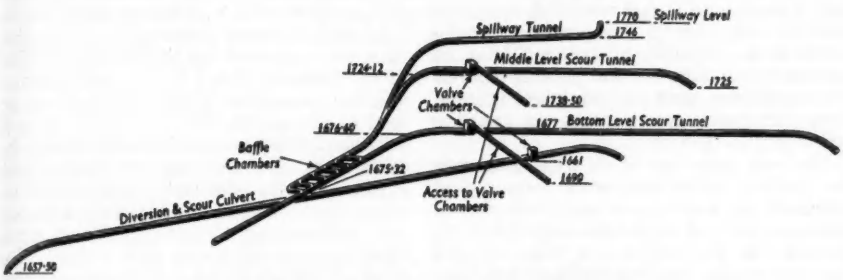


Fig. 59—Discharge Tunnels at Beauregard Dam

During construction, a rubble cofferdam with a concrete cut-off wall has been built above the dam site and the stream diverted into a culvert, which will later form one of the scour pipes of the reservoir. As with several other high dams which have already been described in this article, means for emptying the reservoir will be provided at several levels, and the tunnels which will be necessary for this purpose are shown diagrammatically in Fig. 59; the baffle chambers for dissipating the energy of water spilled from the higher levels may be noted. Aggregate and sand for the dam are quarried from the river bed upstream, and transported by truck to the crushing, screening and concrete mixing plant. The plant at the dam site includes a large compressor house, supplying air for tunnelling and construction generally, in which compressors of British manufacture are in use.

So far the tunnelling works generally have been in hard rock, such as mica schist, and have been fairly straightforward—not unlike much of the tunnelling for the Scottish hydro-electric schemes. At the power station the access tunnel was first excavated, then a space under the roof of the power station was excavated, and the roof concreted; next, trenches were dug to form the walls, and, finally, the central dumpling was removed. Further excavation was necessary for the penstocks, which are to be of normal steel construction, mounted freely in their tunnels.

Transmission and Thermal Generation

Amongst the transmission lines of the S.I.P. group is a 220kV line from the Cardano power station near Bolzano to the substation at Turbigo, and thence to Turin, which, the company states, was the first line at this voltage to be built in Europe; it has a total length of 370km. In the western region there is a second 220kV line, which makes a connection with the French system through the Petit St. Bernard, at an altitude of 2213m. This line runs to the substation serving Malgovert power station on the French side, and as far as Avise power station in the Aosta Valley (Dora Baltea) in Italy, where the transmission voltage changes to 150kV. The line then passes through substations at Pontey and Chatillon, on its route to Turin. The section from the frontier to Avise was originally at 150kV; a new 220kV line is planned as far as Turin.

The Petit St. Bernard - Avise line was built in 1948-49, with a construction period of about twelve months. The design of the towers is of tubular steel, generally similar to the Montecatini Company's 220kV line described earlier in this article. The conductor cables are in aluminium and steel and the earth cables in steel coated with zinc. The route was divided into two zones—"mountainous" and "hilly," according to the severity of the conditions. For the mountainous zone the worst conditions envisaged were a temperature of −5 deg. Cent. and 5kg of ice per linear metre, with corresponding figures of 0 deg. Cent. and 2kg for the hilly zone. The tension in the cables was calculated for temperatures of 0 deg. Cent. and 20 deg. Cent., respectively, in the two zones, giving a maximum of 1850kg and 1810kg, respectively, maintained constant for all spans. Then the maximum tension under the worst conditions as quoted above in the mountain zone was calculated to be 7000kg for the largest span of 546m.

As is the case with other companies, the S.I.P. group has found it necessary to have some thermally generated power in its network. It therefore has under construction very near Turin a thermal power station with a capacity of 100MW in two similar sets, with provision for increasing the capacity to 200MW. Apart from this development there were only two small thermal power stations, totalling 50MW, belonging to the Vizzola Company, in the S.I.P. network.

It has been possible in this review to pick out only some of the more interesting amongst the Italian Alpine hydro-electric schemes, and to mention points of particular interest in their design, either from a historical point of view, or because they represent the most recent Italian practice. There are very many power stations, perhaps not very large, and incorporating no great novelty in their design, which have not been mentioned but which, nevertheless, make an important contribution to Italian power requirements. As the works of each company have been described, however, an attempt has been made to indicate the importance of works such as these, whilst devoting more space to the more outstanding technical achievements.

Our thanks and acknowledgments are due to each of the various power companies mentioned, for their co-operation with this article, and in particular, to the assistance given by the Societa Edison.

Industrial Ceramics.—We have received from Doulton and Co., Ltd., Albert Embankment, London, a booklet entitled "Shaping the Needs of Industry," which discusses industrial stoneware and the "battle" against corrosion, the place of porcelain in the laboratory and in industry, and the use of ceramics in the service of electricity. One section of the booklet is concerned with porous ceramics and their possibilities, and describes how their degree of permeability and chemical inertness make them suitable for the purposes of filtration and clarification, aeration and diffusion and for other applications such as in electrolytic processes.

The Institute of Metals

ANNUAL GENERAL MEETING

No. II—(*Continued from page 503, April 3rd*)

SOME further abstracts are given below from the discussion on the symposium entitled "The Control of Quality in the Production of Wrought Non-Ferrous Metals and Alloys," which formed part of the Institute of Metal's Annual General Meeting.

Mr. N. Kasz (British Aluminium Co., Ltd.): Turning to the question of casting, and first of all chill casting, it still seems to be too little realised that in the ordinary chill moulds the heat exchange involved is in the unsteady state, and in such a case it is not at all surprising that heavier moulds, and even water-cooled copper moulds, soon reach the limits of their possibilities, as the authors put it.

Semi-continuous casting presents its own problems, but, as the authors point out, it is a nearer approach to unidirectional solidification. The coarse grain is in some cases a disadvantage, and it may be an advantage to refine the grain to avoid as-cast cracking. I should like to know whether they have tried that to remove radial cracking ? We cannot agree, however, that grain refinement is essential to final sheet properties. We have on many occasions rolled experimental blocks with crystals up to 12in in diameter and obtained perfectly satisfactory sheet. If you must refine the grains, then to do it by the addition of titanium and boron salts is often a very expensive way of doing something which can be achieved much more cheaply. The shallow solidification may minimise shrinkage and gas porosity, but so far as gas porosity is concerned I should be surprised if it did it by ejecting automatically the gas, as the authors suggest. The major difficulties of the D.C.C. method are this cracking—the fact that we are moving a hot-short thin shell past a stationary mould —and rather marked inverse segregation. The authors seem to attribute the cracking to one or other of two causes. Super-solidus cracking undoubtedly occurs, and there the work of the Birmingham investigators can be usefully applied, but the authors seem to explain the sub-solidus cracking, which occurs, entirely in terms of age. I find it extremely difficult to accept that.

Mr. J. E. Newson (Vickers-Armstrongs, Ltd.) : The first paper in this series which I read was that by Dr. Singer. This is designed as an introduction to the whole series of papers on the control of quality, but I was disappointed to find no reference to the control of quality in melting and casting until I reached the very end of his contribution, and then I learned to my surprise that only one primary variable is always controlled in the melting operation, namely, temperature, and, in his words, this is a depressing state of affairs. In my own experience, extending over about thirty years, we have always endeavoured to control, I think with a fair measure of success, the chemical composition of the melt, the structure of the ingot, the properties of the ingot, and the external characteristics of the ingot. I admit that we did not define these qualities as primary or secondary variables, but we paid considerable attention to such details as rate of pouring, temperature of pouring and mould dressing, to secure the result desired. That is not to say that there is no scope for considerable further improvement beyond the reasonably high standard which has now been achieved in the casting process, for, as we learnt on a recent visit to the U.S.A., there is always a better way. I think, however, that Dr. Singer is rather pessimistic in assuming that the other primary variables which he mentions are not more generally controlled. He says that the reasons for the relative absence of control are, of course, the associated practical problems, which are undoubtedly of considerable magnitude. With this I entirely agree, but I find it very difficult to apply his four conclusions to the subject now under discussion, melting and casting. The paper by Dr. Singer appeared to me to contain so much that is fundamental to the subject of the control of quality, that before turning to the other papers I read it again, and more than once. Like Mr. Christopher Smith, I found some difficulty in absorbing all that the author had to tell us in the early part of the paper, but I came to the conclusion that it would be extremely difficult to apply automatic control mechanisms to most of the problems of melting and casting, but that in other sections of the industry, such as rolling and forging, there are great opportunities of applying scientific quality control.

The only point on which I disagree with the authors is in their section on mould dressings, in which it is suggested that a small quantity of liquid dressing should be poured into the bottom of billet moulds after the surface dressing operation has been completed, to reduce or eliminate roughness on the lower few inches of the billet. Unfortunately, we find that this leads to cold shuts and unsoundness, and we do our best to avoid it by dressing the mould as shortly as possible before casting. If the mould is closed and dressed too long before casting, some of the surface dressing accumulates at the end of the mould and a dirty area develops on rolling. I do not think that there is any doubt at all that the improvement in the quality of our products is one of the major factors in productivity. It is not simply a question of output per man-hour ; it is the output of good, solid material per man-hour which is really the measure of productivity.

Professor G. L. d'Ombrain (Electrical Engineering Department, Battersea Polytechnic) : As my interest lies in systems of control, naturally Dr. Singer's paper is the one to which I shall devote most of my comments. The first matter to which I should like to draw attention is an unfortunate departure in the paper from what is otherwise standard terminology. Both the servo engineers and the process control engineers have their own glossary of standard terms, and there is a British Standard which is entitled "Glossary of Terms Used in Automatic Control and Regulating Systems," B.S. 1523 : 1949. I would ask Dr. Singer to adopt the terms which are used in that glossary, because it will be most regrettable if, when a considerable interest is developing in the metallurgical industry in control, it should develop separate terms, different from those standard in other fields of control engineering.

I should like to add a few comments about process control. At the present time I would say that process control is on the threshold of many new and exciting events. Until now, process control has had to depend upon a set of standard techniques. We have had proportional control, integral control and derivative control, and combinations of the three. They are inherently—as sold commercially, shall we say—applicable only to one actual measured value. We can have a whole series of them ; we can control the temperature, and we can control the flow ; but we cannot, for instance, except with complicated cascade control, control the temperature in relation to the flow. It would seem, on reading these papers, that you are asking in metallurgical control to have a large number of variables controlled, the interrelationship of which you may know. I do not say that that can always be reduced to automatic control, but it is obvious that it cannot be reduced to the automatic control of a single variable, and at the present moment there is no system available commercially which can take information from, say, eight or nine different factors, feed it in and provide an answer which varies various quantities in the process. I think that in time we shall see this, but not for another ten to twelve years.

Mr. J. R. Handforth (Birmetals, Ltd.): Dr. Singer starts by saying that we have a science of quality control. Have we a science of quality control ? I do not think so. I have read his paper three times, and for that reason have decided not to offer any criticism of it. I should like, however, to submit to you two quotations, which I think should be read in conjunction with his paper. One is only six weeks old, and is from a speech by Pollard at the Institute of Aeronautical Engineers. He said : "Glassmaking has been an art for hundreds of years. Scientists are just beginning to understand and appreciate what the craftsmen have done." The other is about twelve years old, from a book called *As I Remember :* "Great thinkers have taught us not to take philosophers as seriously as they take themselves. They are often repetitious and get away with it, because they say all things in such an incomprehensible manner that by the time one has re-read a sentence five or six times one takes so much pleasure in having comprehended the thought that one forgets how old it is." I submit that we should not regard quality control as a science. We do not want new degrees in quality control ; we do not want a new institution ; we do not want more meetings, and we do not want more technical publications to read. Let us continue to honour those of our authors who, by their hard work and clarity of expression, can keep quality control simple, understandable, efficient and practicable. I should like to raise another practical point, and to add one point which has not received much emphasis in this discussion. Cook and Cowley mention it in passing. They say : "While the economic advantages which the low-frequency furnace possesses . . . may have been the main reason for its introduction as a melting unit for brass, its adoption by the industry has itself been a major contribution to the maintaining of a high quality of casting." What I want to say is, is not that usually the case ? To put it bluntly, economic considerations have probably had more effect on quality than all the skill of the metallurgists and physical chemists. Let me quote one example. Many years ago I worked with an aero-engine firm and we made gudgeon pins. The piecework time for the grinding of those gudgeon pins was one hour. We introduced a new machine, a centreless grinding machine followed by a mechanical lapping machine, and the time of production of those gudgeon pins was changed from one per hour to 1800 per hour, with a much higher quality job.

Taking that back to the foundry, let me quote you some figures showing the change in output in one foundry during the last few years. In 1946, the weight cast per man was 199 lb; in 1947 it was 200 lb; in 1948, 241 lb; in 1949, 260 lb; in 1950, 280 lb; in 1951, 327 lb; and in 1952 it was 403 lb per hour per man. What do those figures mean? They do not show, as the little-minded might suggest, increased pressure on the workmen. Rather the reverse. They show the results of progressive and more efficient organisation and, what is more to the point in this discussion, the more efficient handling of the metal and, with the more efficient handling of the metal, its better quality.

Mr. P. F. Mills (James Booth and Co., Ltd.): Dr. Singer has remarked, with regard to statistical control of quality, that the quality control chart is now a familiar sight in metallurgical industry. This makes very good reading, particularly to those who are interested mainly in the inspection aspects, but I must confess that it does not accord with my own experience. In my own experience, which, I hasten to say, is limited, I have come across only one instance where statistical methods were used to control a metallurgical process. That was in an American factory, where steel drop forgings were being controlled. Even in this case, although the nominal purpose of the control charts was to control the quality of the forgings, what they really did was to present a picture of how the forging dies themselves were wearing during operation. For semi-manufacturing metallurgical operations statistical control presents fascinating possibilities, but I should welcome some information from Dr. Singer about the types of semi-manufactures which lend themselves to such statistical control. In asking for this information, I have in mind the difficulty of quickly and precisely measuring primary variables.

Dr. C. J. Smithells (past-president): I wish to make just one point which I do not think that any speaker has emphasised so far. The subject of the discussion is the control of quality, but before we can control quality we must understand thoroughly the particular factor which we are going to control. There are still many factors which can be controlled about which we do not know enough for these control mechanisms to be applied. We shall not discover what we need to know by innumerable factory trials followed by statistical analysis of the results, but only by fundamental work in the laboratory, based on a proper understanding of the real phenomena with which we are dealing. I do not want a meeting on the control of quality to take place without someone saying that there is a great deal of work to be done on the cause of the quality defects before we can apply any methods of control to it.

Mr. Bowen (Imperial Chemical Industries, Ltd., Metals Division): By far the greatest amount of quality control is concerned with the human factor, and I would ask how this is done. For instance, do we feel that the average person in the shop or in the foundry is the measure of his American opposite? Does he, for instance, know the part that his quality control is playing towards the end product? Do any of you here, I would ask, have schemes for instructing furnacemen, individually or by classes? Do you give your furnacemen, or the next up in responsibility, handbooks with pictures illustrating in general terms the main points in the operations which have to be watched? These have to be directed to people whose metallurgical knowledge is very scanty and who know the processes only in terms of a series of operations which they have done for a long period of time. Have any of you an answer to the difficulties which attend the state of mind of a person who is doing the same job day after day and year after year? It is very difficult to bring home to such a person the very great importance of doing the job which he did on Monday just as well for the next weeks, months or years. It seems to me that all these schemes stand or fall by the actual implementation of them on the shop floor, and a scanty scheme carried out by a keen person will triumph over the most detailed and carefully prepared one in the hands of someone who does not devote much care to it.

Mr. Cartwright (Imperial Chemical Industries, Ltd., Metals Division): I wish to refer to a point which is raised in the paper by Cook and Cowley, which seems to me to have been misunderstood. They say that "It does not suffice for details of techniques to be known to those immediately concerned and passed on by word of mouth. . . . They should take the form of written records in which the procedures to be followed and conditions to be observed are set out with clarity and precision." They say, "They should," and not "In our case they do," and in fact I feel sure that they do not. My reason for speaking is to emphasise the real necessity for these details of techniques to be put together for the use of the staffs. These records are not only necessary as a basis for the development of controls, but essential to the development of improved techniques. To be of real value, the record must contain the experiences of the practical metallurgists who may have spent many years in direct control of the plant, together with the information gathered by research and other technicians in the many investigations which they carry out.

Mr. Talbot (British Aluminium Company, Ltd.): It is comparatively easy to obtain results in research, but very difficult to apply them to commercial practice. I wonder whether we are not trying to take instrumentation too far. X-ray sets are out of place in the casting shop, and in any case we require technical assistance to operate anything more complicated than a thermocouple. How far are these things necessary?

Mr. A. B. Graham (Henry Wiggin and Co., Ltd.): I am wholly in sympathy with Dr. Singer, and I think he has a trait of H. G. Wells about him which should be encouraged; but there must be moderation in all things. People often consider productivity to be a matter of producing either tonnage or quantity, with a certain amount of quality, without giving any consideration to price. We can pursue these ideas of control to a considerable extent, but we must not end up in the bankruptcy court.

Afternoon Session

At the afternoon session on March 25th Mr. Paton opened the discussion.

Mr. Charles Paton (Northern Aluminium Company, Ltd.): Some reference has been made to the wonderful reputation which this country has built up abroad for the quality of its products and nobody would question that; but I have worked in American, British and Canadian plants and I have noticed that there is a difference. I think that there is more emphasis in this country on the control of quality at intermediate stages, but I am not convinced that in some cases we do not overdo it. I may be criticised for saying this, but I think that we have to take a second look at some of these places where we are controlling quality. It seems to me that one thing which we must establish in this study of the control of quality is just what items must be controlled in order to effect the desired improvement in quality. Dr. Singer has mentioned a way of recording grain size and feeding back the information to the other end, but it would be a very difficult job, as Dr. Smithells has pointed out, to interpret that information in such a way that you could really affect the grain. My limited knowledge of metallurgy tells me that it is a function of the previous history of that slab, a function of the spacing of the previous inter-anneals and also of the time taken going through the furnace. A similar argument could be used for preferred orientation, which is an extremely complex problem, going back to the hot mill and the interspacing of anneals. We have to be aware of the problems of controlling quality at these intermediate steps. Probably the principal difficulty in a melting room in these days is to minimise blister and inclusions. I was interested to hear Dr. Smithells state that the blister problem is not a serious one with his company, but I should like to question him a little further on that, because, while I think that in the companies of which I have had experience this matter has been brought to some extent under control, we still have very serious blister epidemics. I recall that when I was a junior technician in some of these plants before the war we made very exhaustive studies of the causes of blistering to see whether we could not isolate the principal underlying factors, but I do not think that we were ever successful. It seems to me that for eleven months in the year you can control metal carelessly in the furnace and cascade it down launders and yet everything goes well; and then, in the twelfth month, everything goes wrong! In a way we have to be sympathetic towards the melting room people. If we run into trouble in the sheet mill a careful study always proves that it is a defect in the ingots coming from the ingot room, and in the tube mill trouble will be traced to a defective tube bloom, which goes back to the melting room. Unfortunately, the melting room has no readily available scapegoat. The smelting plant is probably tucked away in Northern Canada or in the Highlands of Scotland and now they are moving the frontier to British Columbia, so that it becomes increasingly difficult to track these things down. Perhaps Dr. Smithells will elaborate on the effect of the incoming ingot on blister control.

Frequent reference is made in all the papers to the use of the Pfeiffer instrument for the control of gas in metal. Since I have confessed that I am not aware of a real cure for blisters, perhaps I am not well qualified to discuss gases in metals; but it is our impression that there is no consistent tie-in between gas in the metal and blistering. There is another factor. You can plot curves which will show a trend, but the gas and the oxide must occur simultaneously. If there is gas, but no oxide about which it can settle or no oxide to form flaws in the ingot towards which it can diffuse, you will not have trouble. Our experience has been that the Pfeiffer instrument is not a bad measure of the gas in the metal but does not necessarily indicate the chance of the ultimate sheet showing blisters. I think we shall all admit that, while control of melting procedures is very important, careless pouring can undo all the good which has been previously done. I do not think that we shall agree with some of the authors when they indicate that holding periods of one and a half hours are necessary. If we are not in that twelfth month to which I have referred previously we find that a very limited holding period, perhaps fifteen minutes, is adequate. If your metal quality is such that you need

one and a half to two hours to clear it up it is best to flux with chlorine or aluminium chloride, but if you have managed to get first-class metal to the pouring spout it is important to get quiescent transfer to the casting machine. The importance of this increases, I believe, as the weight of the cast increases. Some mention is made of the grain refinement of the aluminium-manganese alloys by the use of proprietary fluxes. I am very much interested in this, because it has always been our experience that there is little relationship between the grain size in the ingot and the grain size in the finished sheet. Some of these boron fluxes will give a very fine grain in the ingot, but you can have a very coarse grain in the finished sheet unless you observe the precautions of two inter-anneals preceded by cold work. That puts some very serious problems to companies which have put in these large continuous hot lines and are hot rolling to light gauges. I think that the control of this grain is more a matter of the coalescence of the manganese constituent, and this can be controlled better by casting methods or by preheating than by any grain refinement.

Dr. C. J. Smithells: Before we can do anything about controlling the effect of gas in metals and blistering we have to develop an accurate method of gas analysis, which has not existed before. We should like to be able to do a continuous gas analysis. We must start off with the scientific approach to the problem of having proper methods of measurement, which require a great deal of development. The Straube-Pfeiffer is a very crude instrument. The other factors which Mr. Paton mentioned come into it. The kind of troubles which Mr. Paton has described are exactly those which will face industry so long as industry proceeds on the hit-and-miss method of trying to work on experience and not getting down to the scientific basis of the various controlling factors.

Mr. N. I. Bond-Williams: The statistical methods which Dr. Singer has advocated in his paper suffer from certain limitations. We have heard about them in general terms from other speakers. The limitation which I think is most important is probably based on a diagram which appears in nearly every work on statistical quality control. In that diagram there are three lines, each related to the number of rejects. A straight line through the origin represents the cost of the rejects. An apparently log. curve represents the cost of the quality, and a loop at the top represents a combination of the two, so that it appears that the lowest cost is met by a certain proportion of rejects. Nearly all the work done on statistical quality control has been based on the results of experience in machine shops and press shops and so on, where the line representing rejects and the line representing the cost of quality bear that sort of relation, and the point at which minimum cost occurs is somewhere in the order of 90–95 per cent acceptance and 5–10 per cent rejects at the outside. When, however, we come to consider castings which are to be used for further fabrication into semi-finished products, we find nowadays that for other economic considerations it is to our benefit to make those castings as large as possible, and we have heard to-day of castings of up to 10,000 lb of light alloys. To apply the type of curve which I have drawn, without reflection on the slopes of the two lines, to castings or pieces of that size is unjustified. I think it is possibly the root of the objections to statistical quality control as such in relation to the casting of these large ingots. One can imagine that the cost of rejection line would become very much steeper, and the log. curve relating cost of quality to the number of rejects would become very much shallower when considering those circumstances. On the other hand, the law of probability on which the statistical method is based has quite a number of valuable uses, in my opinion, which have not been touched on in dealing with the control of quality in casting. One in particular is the accuracy of composition. It is my experience that when making up charges for alloys the greatest swing from the expected composition occurs with the lowest number of components in the charge. By increasing the number of separate weighings the accuracy of composition is increased. This, I think, would be borne out by consideration of the probability curves of composition of each of the particular items and the probability curves of the statistical accuracy of the weighing operation; so that a number of weighings of a number of batches of material are more probably accurate in the long run than a few weighings of a few varieties of material. That has been observed by one or two of the authors and also by speakers in the discussion this morning, although no direct reference was made to the statistical background for that.

Professor A. J. Murphy (University of Birmingham): It seems to me that the great value of this symposium is to bring together men with profound experience of different sections of the non-ferrous industry. Reading these five papers from the industry, it is quite surprising to see some of the differences which exist, and even when allowance has been made for the different characteristics of the metals, it is surprising to see how much room there is for differences of practice on the question of methods of casting ingots. I hope that one effect of this meeting will be to reverse any tendency which may exist for cleavages in established practice to grow up and be maintained between these different sections. I think that it would be tragic if anything like the same cleavage were to grow up as unfortunately exists to-day, for instance, between the non-ferrous and the ferrous metals industries, where anybody who moves from one to the other sees on every hand lessons which have been learned years ago in one, still being painfully learned in the other. If we look through all these papers we see at once some common factors. You can pick out what the different operations are and assess to what extent those operations are relatively under control. Take batch casting, the ordinary, conventional casting of a few years ago. We see that the control is pretty good in, for instance, the selection of raw materials, melting (especially if we can use low-frequency induction melting), and in temperature to a certain extent, but here I would emphasise what has been said by one or two other members, that the state of the art as regards the maintenance of pyrometers for the measurement of the temperature of molten metal is rather poor. If we look at some of the other stages in the production of the ingot or billet, we are bound to admit that control is far from being in a satisfactory state. Look at mould dressings, for example. When specifications are drawn up—which is the first stage of progress in control—we find that we really are not so very far away from the specifications and prescriptions which we find in Macbeth:—

> "Eye of newt and toe of frog,
> Wool of bat and tongue of dog"——

and so on, because the materials that are used in the dressings and the specifications of them cannot by any stretch of imagination be related to a pure function. Feeding is another operation about which there is still, to me, a surprising difference of view and of practice. All these considerations have a new significance when one thinks of the advance of continuous casting, because you will see at once that quite a number of these ill-controllable variables present no difficulty at all. The question of mould dressing is practically settled without much debate or anxiety, and the mould surface becomes a more stable and less troublesome thing, and the problem of feeding is almost completely and automatically settled. Reflecting on these considerations, I come to the view which has already been very well expressed by Dr. Smithells. I would put it in this way, that control becomes the less precarious and the more reliable as the true understanding of processes advances. An important stage in this progress is the ability to isolate, and then to measure, the significant factors. While waiting for this development, which may take some time, we must realise that control is made unduly onerous by measuring an unnecessary number of data, many of which are ultimately shown to be irrelevant. This strikes right at the root of one of our problems to-day, which is the provision of sufficient numbers of suitably trained men in industry. As time goes on it is not surprising, with the elaboration of processes, that the demand for men who have been technically trained and are capable of taking positions of responsibility in production increases rapidly, but we can lessen the pressure and lessen the suffering from the lack of those men if we can so analyse our processes as to reduce the number of stages at which close control has to be achieved. Our best hope of arriving at that position is to examine, analyse and understand the function of each variable.

Dr. C. E. Ransley (Research Laboratories, The British Aluminium Company, Ltd.): What can be done about the routine control of quality so far as gas content is concerned? Vacuum extraction determinations are useful only for enclosed processes, and there is no casting shop test which meets the case. The vacuum solidification test has its uses, but is not sensitive enough for this kind of work. The gas content of a freshly melted bath is a very variable quantity, and at the moment all that we can do to ensure adequate quality is to specify degassing treatment which can cope with the worst conditions that arise. This solution is wasteful of both time and material. The ideal solution would be to be able to read the hydrogen content of the metal accurately on the spot, so that each melt could be degassed individually to the desired level. This is a difficult but not an impossible goal. We have devised an instrument which does read the gas content of a metal directly, and we propose to try to develop it to meet this demand.

Monsieur W. Vinaver (Compagnie Asturienne des Mines, Douai, France): Mr. Christopher Smith, when he spoke this morning, wondered why continuous or semi-continuous casting is not applied to zinc. I do not know whether the authors of the paper on zinc casting will agree with me, but my opinion is that in the case of zinc the benefit which could be expected from continuous methods of casting is much less than for other metals. In the first place, even when zinc is cast by continuous or semi-continuous methods a very coarse columnar structure results. For zinc, the influence of rate of cooling on the grain of the metal is very low. When casting zinc by the continuous casting technique the very quick cooling of the ingot results in internal stresses which may afterwards result in cracks during rolling.

(*To be continued*)

Coal Blending Plant at a Steel Works

A coal blending plant with a capacity of 300 tons an hour laid down at the new Shotton works of John Summers and Sons, Ltd., has been designed to overcome the difficulty of maintaining a required coal specification for coke-oven feed with a number of coals of widely varying coking characteristics. It is stated to be the first plant to use the Robins-Messiter system for coal blending.

IN designing the coal carbonising section at the new Shotton steel works of John Summers and Sons, Ltd., a problem was presented by the fact that a dozen or more coals of widely varying coking characteristics had to be blended to ensure maintenance of the required coal specification for the coke oven feed. A further difficulty was that some of these coals, being prone to spontaneous combustion, could not be stored without danger for more than three weeks. The use of blending bunkers and normal coal storage means were investigated and finally rejected in favour of the Robins-Messiter system of bedding and blending. This system was introduced to the United Kingdom by the Fraser and Chalmers Engineering Works of the General Electric Company Ltd., in conjunction with Hewitt Robins Inc. of the United States. It was originally developed for blending ores, and amongst the installations at work in this country is one at the Corby Works of Stewarts and Lloyds, Ltd., which was described in our issue of April 29, 1949.

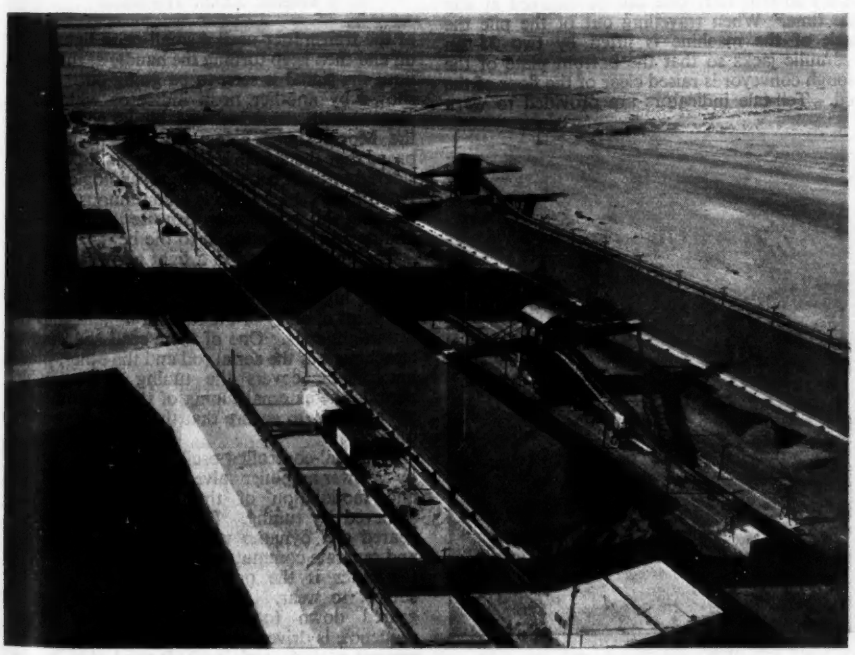
The plant at Shotton has a handling capacity of 300 tons an hour, and we are informed by the General Electric Company, Ltd., that four major considerations influenced the decision to install it. First, accurate blending of large tonnages could be successfully obtained as the basic principle of the system is applicable to all bulk materials; secondly, the space available would accommodate a sufficient number of piles for ample coal storage; thirdly, the reclamation of the piles would recover all the coal and no "dead" pockets would remain as a fire hazard; fourthly, since the coal stored would be blended with those coals liable to spontaneous combustion mixed with others not having such a characteristic, and the fact that coal piles would be reclaimed in rotation, the dangers of spontaneous combustion would be reduced to a minimum.

The Robins-Messiter system consists of two separate operations; first, bedding of the material, where a number of thin layers of coal are made into a pile, and, secondly, reclaiming, where each stroke of a reclaiming machine harrow removes and intimately mixes a true cross section of all the layers in the pile.

In the bedding operation, travelling wing trippers automatically traverse the length of the bed depositing thin layers of coal one above the other from end to end of the pile. Accurate blending which requires approximately the same amount of coal in each layer is achieved by ensuring that the feed to the conveyor system is regular, and that in the event of the feed being interrupted the tripper is stopped immediately until supplies of coal are resumed. Two speeds for the travelling wing tripper are provided since, when travelling away from the feed end of the belt, it receives less coal than when travelling towards the feed end. Reclaiming from the piles is carried out by a machine which is a travelling bridge carrying two units, a harrow and a plough conveyor. The harrow, fitted to the front of the machine, reciprocates slowly across the face of the pile, dislodging a small cross section which, as it rolls down into the plough conveyor, is intimately mixed by hundreds of tines equally spaced over the harrow surface. The inclination of the harrow is adjusted to the angle which gives a steady flow of coal down to the conveyor. The reversible plough conveyor then carries the blended coal to either side of the machine as required. When the machine has cleared one pile it is run back and by means of a transfer car is set on another track to deal with the next pile.

The plant installed at Shotton is arranged at present for making three piles, each of 12,000 tons capacity and 975ft long, a length far in excess of any previous installation. Equipment for a fourth pile is now on order and further space available will enable a fifth pile of 12,000 tons capacity to be made and a sixth pile of lesser capacity, should such additional capacity be required. The whole of the operation of blending and reclaiming is carried out by only two men, one wing tripper operator and one reclaimer operator.

Travelling Wing Tripper



Coal Blending Plant

Three reclaiming conveyors only are provided, so that when equipment for the fourth pile has been installed there will be one conveyor down the outer edge of each outer pile and one running down the gap between the inner piles. Thus, each outer pile is reclaimed through a central conveyor by reversing the direction of the plough conveyor.

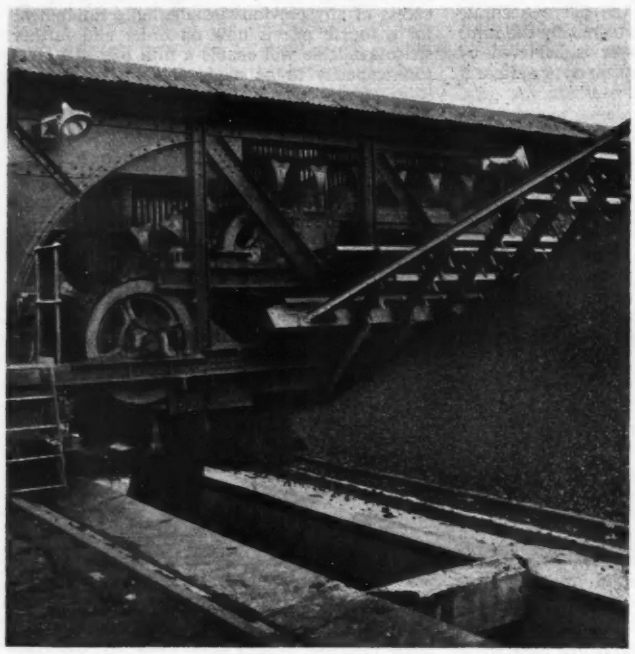
The equipment supplied includes two wing trippers, two reclaimers, a transfer car and two "Sherwen" feeders supplied by the Fraser and Chalmers Engineering Works. All the belt conveyors and civil engineering equipment were designed and supplied by Simon Carves, Ltd., as part of the complete coke-oven contract which was placed with that company.

Coal from the railhead is fed by the two "Sherwen" electromagnetic vibrating feeders to a transverse conveyor, which in turn discharges to the wing tripper conveyors. These two 42in reversible travelling pile-bedding wing trippers, one of which can be seen in a photograph we reproduce, are built up of mild steel framework braced by lattice girders.

Two cantilever frames form the boom conveyor structure, one being on each side of the travelling wing tripper frame, and the outer pulleys of these conveyors are set at 103ft centres. Four two-wheel articulated steel bogie frames form the undercarriage of the machine, which has a track of 16ft. The trailing bridge is inclined at an angle of 16 deg. and it is fitted with channel stringers to receive the troughing idlers of the conveyor carrying the coal up to the boom conveyors. The upper end of the bridge is attached to the tripper frame by hinge pins, the lower end being carried on a supporting framework extended each side, and upon these extensions are mounted the travelling wheel bogies.

The machine is propelled by a two-speed,

double-winding, continuously rated 40/27 h.p. electric motor running at 720/480 r.p.m., giving a travelling speed of up to 75ft per minute on the return journey and 50ft per minute on the outward journey. Drive is transmitted through a worm reduction gear fitted with a hydraulic coupling and solenoid brake ; spur reduction gears and cast steel crown gears forming the final drive to the axles. The electric supply for the motors is from overhead collector wires, using three-phase a.c., 415V, 50 c/s current. The boom conveyor is driven by a 10 h.p. squirrel-cage motor at 720 r.p.m. through worm reduction gears and a flexible coupling. In the general view we reproduce showing the machine in operation, there can be seen a completed coal pile at the left-hand side, with the spare reclaimer at the far end, and another pile being made by the tripper in the foreground.



Reclaimer Harrow and Plough Conveyor

The reclaiming machines are designed to operate against the face of the coal pile, which has a triangular cross section with a base 56ft wide and a height of 21ft 6in to the apex. Normally, one machine is in use, with the other as a spare. The machine is built in the form of a travelling bridge spanning the width of the coal pile and has a wheel track of 75ft. Its operational speed is from 0·1ft to 0·8ft per minute in a forward (reclaiming) direction, with a rapid backward travel of 30ft per minute.

Mounted upon the main bridge structure is the harrow to be seen in one of the illustrations. This harrow makes a complete uniform cross-section cut at eighteen strokes per minute with a 24in travel. It is driven by a 15 h.p. slipring motor fitted with a hydraulic coupling driving through a worm reduction gear, upon the final drive shaft of which is mounted the crank pin with a 12in throw which operates a connecting-rod driving the harrow. The lower end of the harrow is carried on rollers and is supported at its apex by three falls of wire rope connected to a winch by which its angle can be adjusted to suit the angle of repose of the material.

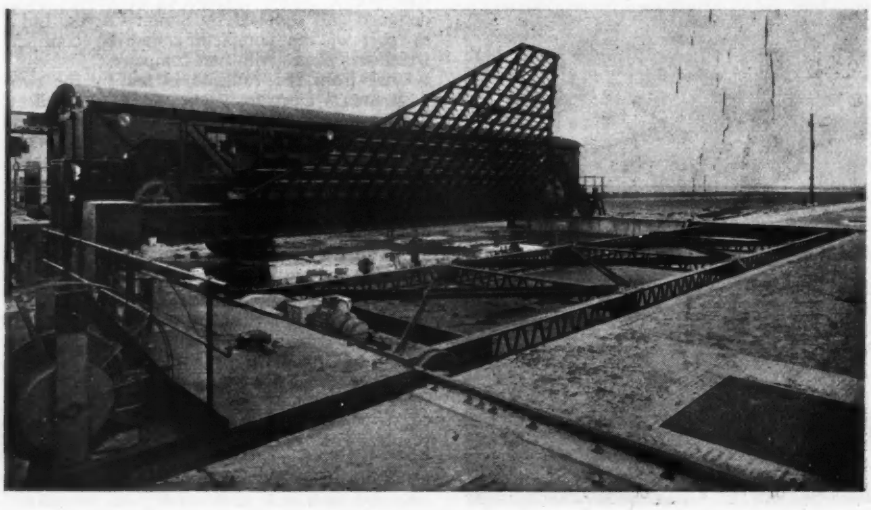
The coal on reaching the base of the pile is collected by a plough conveyor running the length of the foot of the bridge and delivering into the reclaiming conveyor at the side below ground level. This plough conveyor is reversible, the drive for each direction being provided by an 80 h.p. slipring motor. The conveyor is operated by two chains carried in guides, and the ploughs run upon a bottom plate which, in combination with vertical side plates, forms a trough in which the coal is carried to the reclaiming conveyor.

Coal is fed via this reclaiming conveyor to the top of the mill housing, where it is discharged to three interconnected hammer mills in which it is crushed to 90 per cent minus ¼in. From these hammer mills the crushed coal is then fed to the main conveyor for transfer to the service bunker of the coking plant.

Drive for the transverse movement of the reclaimer is provided by a 7½ h.p. slipring motor for the forward (reclaiming) motion, whilst for high-speed backward travel the machine is provided with a 15 h.p. slipring motor. Both drives are connected through a double-jaw clutch so that only one can be engaged at any one time. When travelling out of the pile the back of the machine is lifted by two 35-ton hydraulic jacks so that the bottom plate of the plough conveyor is raised clear of the floor of the bed. Tell-tale indicators are provided to warn the driver in the event of the machine not being parallel to the running rails.

A transfer car provided for transferring the reclaiming machine to different beds can be seen in the foreground of one of the photographs on this page. It is built in the form of an open frame of lattice girders, braced by cross ties and fitted with a rail track of similar span to the reclaimer gauge. The car is carried on eight cast steel wheels with double flanges, and is driven by a 15 h.p. slipring motor through worm reduction gears and a single spur gear to a cross shaft at one end.

All driving motors and electric control equipment for the plant were supplied by the General Electric Company, Ltd.



Reclaimer and Transfer Car

Lifeboat S.O.S. Transmitter

THERE was recently demonstrated in London a new device for saving lives at sea, which has been developed by Venner Electronics, Ltd., of New Malden, Surrey. Regulations provide for wireless transmitters to be fitted in a proportion of the ship's lifeboats, but in heavy seas it is almost impossible for the remaining lifeboats to keep company with the transmitting boat. It was to solve this problem and also to help lifeboats to be found more easily that the company has developed the Venner Electronics automatic S.O.S. transmitter. The device, which we illustrate, consists of a small box measuring 12in by 7in by 5in deep, arranged for bolting to the underside of the thwarts of the lifeboat. The only action required is that one of those in the boat should mount a rod pattern aerial by a simple plug-in action and then turn the handle

Lifeboat S.O.S. Transmitter

of the transmitter until a small neon light comes on and then keep turning the handle at that speed until the signal is seen to be going out. This is shown by another neon indicator which is in parallel with the aerial and blinks according to the Morse signal being radiated. This visual proof that the signal is being transmitted is considered to be of considerable psychological value. Part of the signal given is a continuous tone and rescuing ships or aircraft can use it for direction finding and navigating in to the boat.

The unit is housed in a light alloy casting and there is a close-fitting base with a watertight gasket, lugs for attachment, watertight glands at the point of entry of the turning handle, and two watertight caps. One of these seals the point of attachment of the aerial rod and the other, placed underneath, covers the tuning device, which permits the external tuning of the transmitter by the operator to ensure that the aerial is properly tuned.

A crystal-controlled oscillating valve, followed by a power amplifier valve, forms the transmitter, and modulation of the continuous wave is achieved by tuning. Power is generated by a geared d.c. dynamo with l.t. and h.t. windings and separate commutators, and the brush gear of the latter is the only part of the equipment subject to wear. A signal code disc, which is geared down to provide the signal keying sequence, is driven from the extended end of the generator shaft and is so formed that a continuous alarm interspersed with S.O.S. signals is

sent out. This sequence will continue so long as the handle is turned at the required speed. An optimum speed clutch is fitted, which limits the generator speed when the voltage has risen sufficiently and so acts as an automatic safeguard against overcranking.

No batteries are required and, with regard to maintenance, the company states that no replacements should be necessary during the life of the unit, but suggest periodic examination by a qualified radio operator. The purpose of this inspection is to make sure that the neon and filament indicators are functioning and that the valves have not suffered any vibration damage.

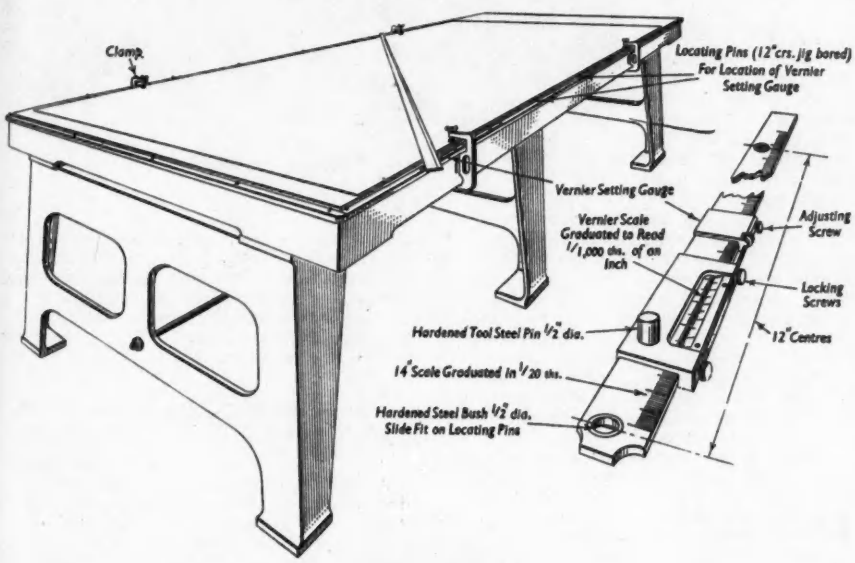
A Precision Lofting Table

WE have received details from Short Brothers and Harland, Ltd., of a precision scribing and lofting table which the company has developed in the light of its experience in producing the accurate external surfaces and profiles involved in high-speed aircraft structures. There, attainment is dependent to a large extent on structural accuracy which is largely achieved through the medium of layouts and templates.

Present-day trends are bringing about an increased usage of full-scale lofting to all kinds of jig making, including that of envelope jigging of major aircraft components. Consequently, the need arises also for accurate templates suitable for automatic profiling machine tools.

The lofting table described here makes available a precise mechanical means of marking out basic grillages, offsets, and the like. It makes use of the vernier gauge and sine-bar principles, and virtue of which the amount of offset between the readings of the vernier gauge on one side and the reading of the vernier gauge on the opposite side can be predetermined for any required angle. On this basis a chart has been compiled from which the offsets for all angles between 0 deg. to 45 deg. in increments of one minute of arc are given, thus any required angle up to 360 deg. can easily be catered for.

The vernier gauges are provided with locating holes, jig bored to exactly 12in centres and fitted with hardened steel bushes to pick up on the locating pins. The blade carries a 14in scale graduated in one-twentieth of an inch, the zero marking of which corresponds to the inner face of the hardened steel bush. The vernier cursor is graduated to read in thousandths of an inch and the hardened steel ½in diameter pin is positioned to be axially in line with the bush and


Clamp
Locating Pins (12"crs. jig bored) For Location of Vernier Setting Gauge
Vernier Setting Gauge
Vernier Scale Graduated to Read 1/1,000 ths. of an Inch
Adjusting Screw
Locking Screws
12"Centres
Hardened Tool Steel Pin ½" dia.
14" Scale Graduated in 1/20 ths.
Hardened Steel Bush ½" dia. Slide Fit on Locating Pins

A Precision Lofting Table

has the advantages of both. Together with the high degree of accuracy in lofting, it is claimed that a time saving of at least 60 per cent is effected on both layout and inspection.

Apart from the reduction of error due to progressive build up on a big layout, errors due to calculations are also largely eliminated. The use of trammels is likewise unnecessary, their use being confined to the scribing of arcs of circles. Base grillage can be marked off at stations and offsets at any required pitch, either parallel or at right angles to one another, or at any required angle within a minute of arc up to 360 deg. without recourse to any calculations whatever. By virtue of the vernier cursors on the longitudinal and transverse scales, linear readings to one-thousandth of an inch can be registered.

In one application two vernier gauges are provided which operate on opposite sides or ends of the table. Rectangular steel bars 1in by ½in are fitted to the sides and ends of the table; ½in diameter pins (the holes for which are jig bored) are pitched at precisely 12in along the bars for the purpose of locating the vernier gauges. Pins on opposite ends and sides must be directly in line with each other.

The transverse pitch between the centres of the pins on the longitudinal members is set at exactly 50in. This provides a "constant" by the fixed steel locating pins, when the vernier is at the zero position. By application of the verniers to any pair of locating pins, measurements up to 10ft, in thousandths of an inch, can be made longitudinally and 4ft transversely.

In marking out, the material is clamped to the table using four specially designed clamps which permit unrestricted movement of the verniers. Assuming that the longitudinal centre line or datum is to be scribed, the vernier gauges are applied, on the central position, to opposite ends of the table with the vernier cursor set at zero. The straight edge is then located against the pegs, automatically bringing the edge of the straight edge in line with the zero markings of the scale and vernier, following which the required line can be scribed or drawn.

Lines parallel to the central datum can be marked in a similar way at any required pitch by the combined movement of the vernier gauge from one set of pegs to another and the resetting of the vernier cursor. With the scribing of lines at right angles to the central datum, vernier gauges are applied to the longitudinal locating pins and the settings are dictated by the number of stations and the pitches required. Should the pitch of the stations be 12in or even factors of 12in, i.e. 3in, 4in or 6in pitch, the marking out process is further simplified by the fact that resetting of the vernier gauges is considerably minimised.

Lines inclined to the datum can be scribed in a similar manner. Knowing the angle, reference can be made to the sine chart which gives the corresponding offset to which the vernier gauges must be set on opposite sides of the table. The straight edge position against the locating pins will give the required angle, and with the aid of linked parallels, the line can be scribed through any desired point.

Similarly, the set square can be projected from the straight edge to give a line at right angles to the base line. Spring clamps are provided for securing the vernier gauges to the table and are for use in cases where the verniers are intended to be stationary for prolonged periods.

A modified version of the table is shown in our illustration. In this case, the fixed locating pins are dispensed with, steel bars being fitted with measuring scales marked in one-twentieth of an inch and covering the full length and width of the table on all four sides. An independent cursor, similar in design to that already described, is fitted to each scale, a ½in diameter locating pin fulfilling the same function of locating the straight edge as previously described.

The distinctive feature of this design is that the fixed locating pegs and the bush holes of the vernier scales of the original design are dispensed with, providing a decided advantage in manipulation and accuracy of setting in cases where the precision layout table is being permanently employed as an independent unit (i.e. unattached to any other layout table). In every other respect, this table is similar to that described and serves exactly the same function.

Square or rectangular wood-topped loft tables and standard cast iron surface tables are equally suited and can be readily adapted to the system. By making the transverse members detachable, a number of tables can, if necessary, be ganged together lengthwise for large area lofting. The greater the table area, the more advantageous the system, as lofting can be commenced simultaneously at a number of points without the fear of a progressive build up of dimensional limits. By this means, the lofting cycle time can be proportionately reduced.

The width of the table imposes limitations on the width of the workpiece, but even with a single unit any length can be catered for by progressive movement of the workpiece along the table.

The purpose of the peg design is to facilitate the joining of groups of tables. By removing the adjacent end members it only becomes necessary to position the tables in line, and with the pitch between the end pegs on each table registering 12in. By this means the vernier gauges will straddle the gap and allow for any lofting requirements over this area.

Technical Reports

The Use of Welding in Steel Building Structures. The British Constructional Steelwork Association, Artillery House, Artillery Row, London, S.W.1.—This brochure, prepared by a committee of the Association, is intended to give guidance on the design of metal arc welded steel building structures under nominally static loading conditions, made in mild and high-tensile steels and designed as simple frames. It is pointed out that a large proportion of constructional work lies within this scope, wherein, perhaps, there is rather more need for education in the use of welding. The various sections of the brochure are devoted to fillet and butt welds and their use in typical structural details; the design of a welded plate girder and of a welded plate crane girder; the design of welded built-up stanchions, and notes on the practicability of welding and on drawing-office procedure.

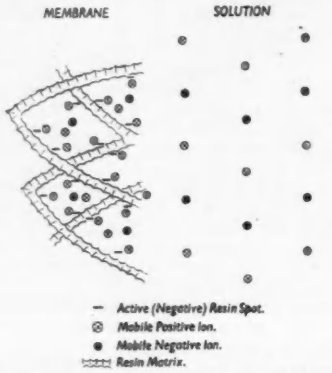
The Performance of A.C. Fuses with Small Over-Currents at 11kV. By H. W. Baxter, B.Sc.(Eng.), A.M.I.E.E., and M. T. Cree. The British Electrical and Allied Industries Research Association (Ref. G/T256). Price 6s., postage 3d.—This is the tenth report in the series dealing with fundamental principles of fuse operation, those immediately preceding it being Refs. G/T245 and 246. It covers further consideration of problems arising on a range of current where operation is inherently difficult and also, unlike the previous reports, deals with tests at a high voltage, viz., 11kV, as compared with 200-400V.

American Engineering News

(By Our American Correspondent)

A Low Cost Process for Purifying Sea-Water

Certain details relating to a method for the "demineralisation" of sea-water, based on the use of electrical energy in conjunction with synthetic membranes, were released recently by Ionics, Incorporated, a research and development company of Cambridge, Massachusetts. The cost of the process is claimed to be only one-half to one-third of that required by the most economical process now commercially available, the vapour compression evaporator. Fundamentally the method is based on the use of synthetic membranes which are being marketed by Ionics, Incorporated, under the trade mark "Nepton." A stream of sea-water fed to a unit using the membranes emerges, after treatment, split into two streams, one being a fresh water stream comprising two-thirds of the volume of the feed and containing practically none of the salt ; the other one being a brine stream amounting to one-third of the volume of the feed and containing all of the salt. The fresh water produced can be used for drinking, industrial or agricultural purposes. The brine must be disposed of, but may first be treated further to produce salt, magnesium or other chemicals derived from sea-water. The energy required for the process is furnished in the form of electrical power. The flows are continuous and the apparatus has no moving parts other



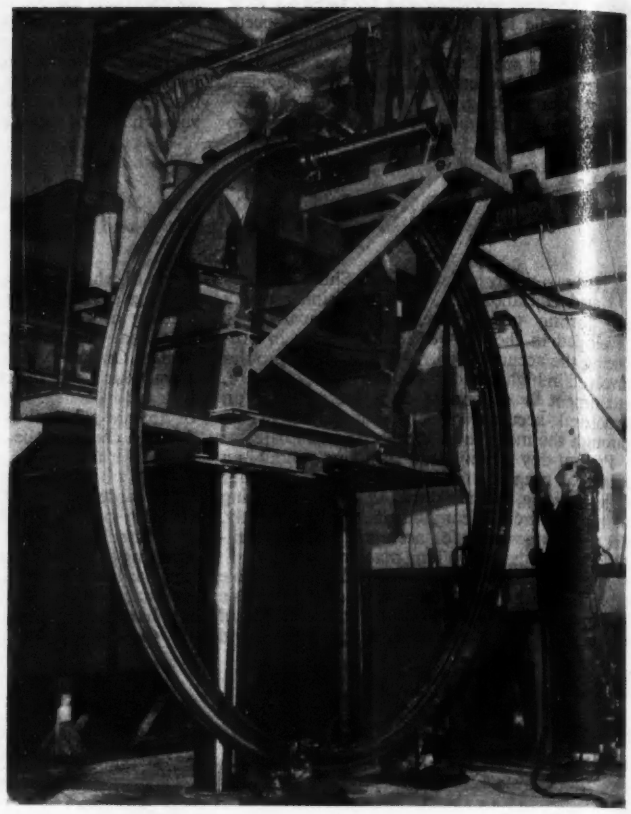
Simplified Molecular Diagram of Cation Membrane

than the water stream. Water pumping costs have been found negligible. The process uses no heat or chemicals. A membrane unit of a given size will purify sea-water over a wide range of flow rates if the amount of electrical power is increased as the sea-water flow is increased. However, the faster the flow the more expensive the fresh water production becomes in terms of electrical energy used per gallon. At relatively low flow rates the energy consumption can be as low as 20kWh per thousand gallons. In many western areas of the United States, where there is an acute water problem, electrical energy is available for as little as 0·3 cents per kWh. Therefore, the membrane units make possible production of fresh water from the sea in such areas for a power cost of only 6 cents per thousand gallons. Because these low power costs in membrane demineralisation are achieved at low output levels and the equipment cost must be added to determine the true fresh water cost, the practical success of this method of purifying sea-water has been dependent on cheap mass production of suitable membranes of long, useful life. These membranes are continuous films of synthetic plastic materials usually varying in thickness from 0·010in to 0·040in, and are made largely of cheap coal tar and petroleum chemicals. In the accompanying illustration there is shown a simplified molecular model of a "Nepton" membrane. The basic structure of the membrane is a cross-linked skeleton of polymetric material which has been described as a "three-dimensional fishnet." In the interstices of this network there is water. At various places in the network there are active charged spots bound into the structure. In an anion membrane these spots carry a positive charge ; in a cation membrane, such as the one illustrated, these spots are negative. Each active spot is countered by an ion of the opposite sign, which is more or less mobile and is dissolved in the water of the membrane. If such a cation membrane is placed in a solution of a salt, there will be exchange of positive ions between the solution and the membrane. However, the negative charges in the membrane cannot move and, at all times, there will be a number of positive ions held in the structure equal to the number of bound negative charges. A membrane is said to be ion-selective when it exhibits preferential transfer for ions of a given sign ; thus, a cation membrane shows high ion-selectivity for positive ions. The discovery of ion transfer membranes and the initial preparation of the film materials is due to Mr. W. Juda and Mr. W. A. McRae, of Ionics, Incorporated.

Plans are now being made for the mass production of the membranes and equipment at sufficiently low cost so that the total cost of sea-water purification with cheap power can be brought to the range of 10 to 20 cents per thousand gallons. Even more attractive than the purification of sea-water with the aid of these membranes is the purification of brackish water. Water is considered brackish when it has been contaminated with moderate salt concentrations (one-tenth to one-fifth that of sea-water) by the intrusion of sea-water or oil well brines into fresh well water, or by the percolation of fresh water through rocks and soils containing soluble minerals. For brackish waters the new process is considerably cheaper than for sea-water. By using the new membranes it is stated that the cost of electrical energy consumed in the purification of many common brackish waters may be as little as 1 cent per thousand gallons. In contrast, the vapour compression evaporator using cheap power now requires about 35 cents-worth of electrical energy to purify a thousand gallons of brackish water. This great economy is made possible by the difference between the basic principle of membrane demineralisation and that of conventional purification by evaporation. In evaporation part of the water is vaporised, the salt is left behind in the "blow down" and the water vapour is condensed to pure water on a cool surface. Thus, it is nearly as expensive to purify brackish water by this method as it is to purify sea-water. By contrast, with membrane demineralisation, the salt is removed from the water by electrical energy and the cost of removal becomes cheaper per gallon of water as the salinity of the raw water is reduced.

Large Expansion Joints for Gas Turbine Plants

A number of 5000 h.p. stationary gas turbine power plants currently being built by the General Electric Company require stainless steel bellows expansion joints of extremely large diameter. The bellows sections, which have an inside diameter of 10ft 2in, are being fabricated by the Solar Aircraft Company, of San Diego, California. Each of the expansion joints, which are used to accommodate thermal expansion in waste heat boiler and regenerator connections, has three convolutions forming a leak-proof joint. The convolutions are made of 0·140in thick titanium-stabilised 18–8 stainless steel, conforming to the American A.I.S.I. Type 321



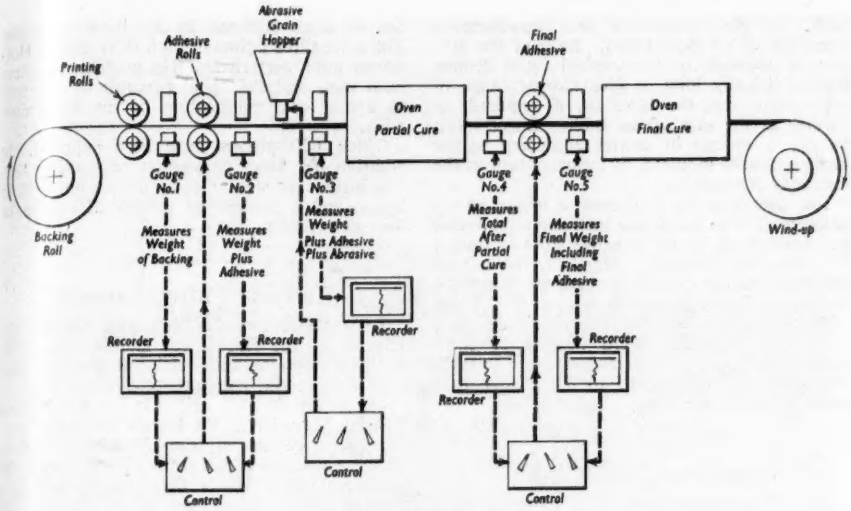
Fabrication of Bellows Expansion Joint

specification, and are attached to standard carbon steel or low alloy steel weld ends. The expansion joints are fabricated in accordance with the A.S.M.E. code requirements for unfired pressure vessels. The illustration above shows one of these assemblies being welded on a hydraulic manipulator which also supports the welding equipment and operators.

An Industrial Application of Beta-Ray Gauging

An interesting application of beta-ray gauging is now in use at the coated products division of the Carborundum Company, Niagara Falls, New York, on a continuous coated abrasive processing line which travels at a rate of up to 350ft per minute. In this particular installation the gauge indications, which are expressed as small voltages, actuate recording devices that provide permanent records of each production run and, at the same time, provide signals for production line adjustments that can be made in a matter of seconds, without stopping the high-speed machinery. The significance of the introduction of beta-ray gauging in the coated abrasives industry is apparent when it is understood that up to now production control has been on a "cut-and-dry" manual basis. Control required stopping of machines, taking of samples, checking of each sample and, finally, adjustment of rolls and feeds. Thus, close control proved costly and the exact reproduction of a previous run was difficult.

Commercial coated abrasives are to-day manufactured in the form of rolls, discs, belts and pads, with many variations in the abrasive material and to many specifications of thickness and density of abrasive. The accompanying diagram shows the layout of a continuous coated abrasive processing line and indicates the five application points of the "Accuray" beta gauges, which were made by the Industrial Nucleonics Corporation of Columbus, Ohio. The gauges provide continuous sampling, are not influenced by external factors, such as temperature, dirt and humidity, and do not contact the moving sheet at any time. A sealed capsule of radio-active Strontium-90 is employed to emit beta-rays. As the



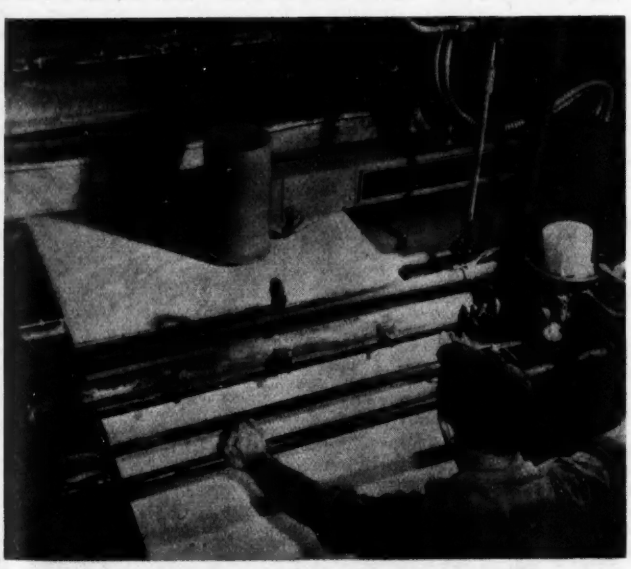
Gauging Installation Diagram

material being measured moves past the aperture between the isotope source and the ionisation chamber detector unit, the amount of radiation passing through the material varies according to the density of the material. The beta-rays penetrating to the detector unit ionise an inert gas and thus create a small voltage that provides a recording and controlling signal. Since the gauge is calibrated, any variations in the rate of beta-ray transmission cause changes in signal varying directly with change in weight per unit area of the material. Five beta gauges are employed on each of the company's coated abrasive processing lines. Gauge No. 1 measures the weight of the backing material. This backing is usually paper, cloth, fibre or a combination of these. Any variation in unit weight at this point affects subsequent coating operations, such as the adhesive roll setting. Hence, this gauge furnishes a base measurement. Gauge No. 2 indicates the weight of the backing plus the weight of the adhesive coat. Gauge No. 3 measures the weight of the backing plus the weight of the adhesive plus the weight of the abrasive. Gauge No. 4 measures the total weight after the preliminary cure and before the application of the final adhesive coating. Gauge No. 5 measures the final weight after this adhesive application. The signals from the gauges are translated into a trace on pen recorders. Thus, superimposing the trace signal from Gauge No. 1 and the signal from Gauge No. 2 on one recorder provides a visual comparison of machine coating. Similarly, the two superimposed signals from Gauge No. 2 and Gauge No. 3 on a second recorder show immediately any deviation from abrasive coating specifications. It is therefore possible to apply proper corrections to the adhesive roll settings. the abrasive feed and the rate of paper feed through the machinery without delay. The illustration below shows one of the beta-ray gauges mounted between the adhesive rolls and the abrasive grain hopper.

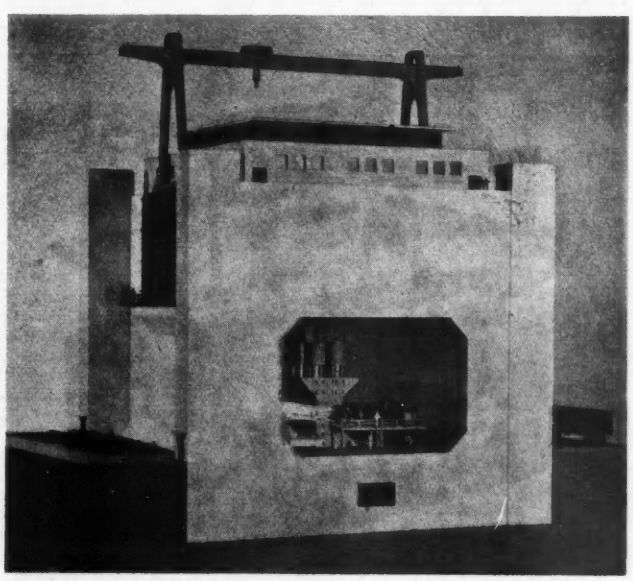
A Throatless Hydraulic Forging Press

An interesting design concept, which will bring very large throatless hydraulic presses with capacities of more than 70,000 tons within the reach of existing machine tools and construction equipment instead of requiring special facilities for their production, has been developed by the Throatless Press Company, of Cleveland, Ohio. The firm was established as a joint subsidiary company of the Austin Company, Cleveland, Ohio, and the Hydraulic Press Manufacturing Company, of Mt. Gilead, Ohio, for the purpose of developing, producing and erecting throatless presses which will provide access over a full 360 deg. for placing and removing dies and work of any size required in closed die forging, rubber pad forming and die quenching. The illustration on this page shows a scale model of the mechanical parts of such a press and of the monolithic concrete structure which would serve the purpose of supporting, suspending and completely housing all of the required press elements and operations. The mass provides the counter force required to resist the tremendous concentrated upward pressure developed in the forging operations and makes unnecessary the extremely large and costly columns and head and base frame castings used for this purpose in conventional hydraulic forging presses.

The original throatless press concept was developed by C. A. Van Dusen, of the Van Dusen Engineering Company, Escondido, California, who envisaged the installation of such large forging presses in caves or tunnels which would give protection against aerial attack and where, he thought, the upper press element might be suspended so that the force of gravity inherent in the natural mass above it would eliminate the need for the very large steel elements which have been causing manufacturing problems. In the past six months the Throatless Press Company, to whom Van Dusen has assigned his rights, has converted this basic idea into an actual engineering design which is now believed to offer a practical solution to the many problems which have become apparent in the design of heavy presses. The present model is representative of a structure with an approximate overall height of 180ft, 30ft of which being below ground level. The frame walls are set 80ft apart and there is a clear height of at least 50ft. below the concrete mass which they support and which forms the enclosure for the operating portions of the press. An initial length of 120ft is planned. Because of the unit design adopted, this length could be increased; dimensions of the bed could be extended, press sections could be added to increase the tonnage or the pressing area capacity, or a line of smaller presses could be installed within a single frame. All of the press components would be supported on the structure in order to utilise their weight as part of the overall counter force and to keep to a minimum the lengths of pressure piping installed. Twelve accumulator bottles weighing some 80 tons each would be mounted high on the exterior walls. A 90-ton capacity travelling gantry would be erected on the roof for use in raising the pressure vessels and in handling the pumps and compressors to be installed on the roof for operation of the press. The prime movers required are expected to have an aggregate capacity of 10,000 h.p. According to preliminary estimates, the installed cost of such a 70,000-ton throatless press, including the entire enclosure and all of the auxiliary equipment, would be substantially less than that required for a conventional 70,000-ton press with comparable auxiliaries.



Beta Ray Gauge



Model of Throatless Press Structure

A Multi-Burner Automatic Gas Heating Equipment

A NEW equipment using gas as the heating medium has been developed by Standard Telephones and Cables, Ltd., of Sidcup, Kent, for soldering, brazing, heat treatment and similar work where rapid localised heating of components to temperatures up to 1200 deg. Cent. is required. Its method of control and operation is such that settings can quickly and easily be varied for it to be used on small batch or long run production working. According to the nature of the components being treated, single or multiple gas jets can be fitted and adjusted to give any heat pattern required. A standard equipment such as that we illustrate on this page is fitted with six jets on each side, but special units with a larger number of jets can be built to requirements. To operate the equipment a normal supply of towns gas, together with compressed air at a minimum pressure of 15 lb per square inch, is required. The units are fitted with electrical controls which ensure economy in operation and permit automatic and accurate timing of operations when close temperature limits have to be observed.

The equipment consists essentially of a sheet steel cabinet base within which there are enclosed the gas mixing, timing, regulating and other units. A heat resistant table mounted above the base is fitted with pillars carrying adjustable burner supports. In the equipment the gas and compressed air are fed into an injector of special design fitted with a sliding regulating sleeve. This injector can be set to give at the manifolds on each side of the base a correctly proportioned air/gas mixture at the required working pressure and it is adjusted in accordance with the number of burners in use. Two needle valves on the main incoming gas and compressed air supply lines are adjusted when setting up the equipment. In these lines between the needle valves and the injector are two electromagnetic valves, which are automatically held in the closed position between heating cycles.

At each burner in use a pilot flame is maintained and a supply of air and gas to feed the pilots is obtained through by-pass lines connected to the main supplies in front of the magnetic valves and delivered straight to the injector. When the pilots are first lit, two valves in the by-pass lines are adjusted to set their flame sizes. Thereafter a constant feed to the pilots is maintained, irrespective of the working of the main burners.

The electromagnetic valves of the main burner supplies are operated either by push-button or by automatic control through the process timer. With these valves the supply of gas and air to the injector is turned off or on instantaneously without dwell or blow-back, to give immediate and simultaneous operation of all the burners. Each of the burners is coupled to its manifold by a flexible pipe sufficiently long to give a wide range of adjustment over the table or, if required, to fixtures at the side of the table. Burners can be cut in or out of service according to the heating pattern required, by means of taps at the manifold connection.

For operating the equipment a minimum air pressure of 15 lb per square inch and a minimum gas pressure of 2in water gauge from at least a 1in main are required. Marshall, fish-tail or pin-point burners can all be used, the respective maximum flame temperatures available being 1500 deg. Cent., 1300 deg. Cent. and 1200 deg. Cent. For special pattern heating of components gas jets can be arranged round suitably shaped manifolds attached to the flexible feed lines in place of the normal burner heads.

Aluminium Roof Girders

ONE of the tram depots of Birmingham City Transport is being converted for the storage of buses and this involves considerable structural alterations since buses require a different parking arrangement from that of trams, and more room to manœuvre. To provide additional manœuvring space alternate stanchions are being removed and the roof girders are being replaced by others of greatly increased span.

The new roof girders, which have been built by Samuel Butler and Sons, Ltd., are of aluminium alloy and have a span of 67ft by 6ft in depth and weigh 2½ tons. By using aluminium alloy the load on the remaining columns has been increased by the minimum amount while the problems of transport and of erection have been simplified.

Each girder is built of plate material in Noral 65 S.W.P. and sections in Noral 51 S.W.P. (H.E. 10), supplied by the Northern Aluminium Company, Ltd., and both are fully heat-treated aluminium-magnesium-silicon alloys, the 0·1 per cent tensile proof stress for the plates and sections being 14 tons per square inch and 15 tons per square inch, respectively. These values are according to specification B.S.1477 but typical values for the alloys are 17·5 and 18 tons per square inch. The maximum design stress assumed in the compression flange was 4·94 tons per square inch, so that there is an ample factor of safety.

The plate web is 5ft 9in deep by $\frac{1}{4}$in thick and consists of seven plates, joined by double butt straps, and stiffened on each side by 5in by 4in or 4in by 3in angle bars generally at 3ft 9in apart. Two 6in by 4in angle bars and a rider plate 14in wide by $\frac{1}{4}$in thick form the tension flange while the compression flange is similar except that the rider plate is 20in wide by $\frac{1}{2}$in thick and has its edges stiffened by 3in by 3in sections. There are three points in each rider plate. Hot-driven mild steel rivets, $\frac{13}{16}$in in diameter, have been used and the usual precautions observed to avoid local overheating of the aluminium alloy.

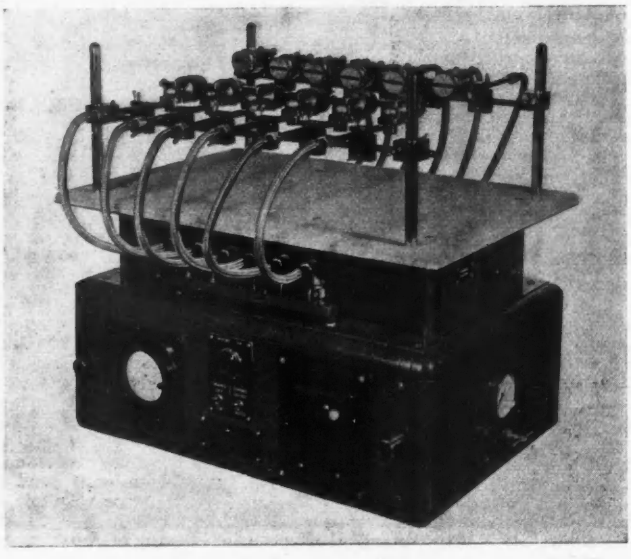
Three 67ft girders have been supplied. In addition the depot conversion scheme requires two girders of similar construction but 50ft in length and a number of girders 23ft long to form door lintels.

Customs Patrol Launch

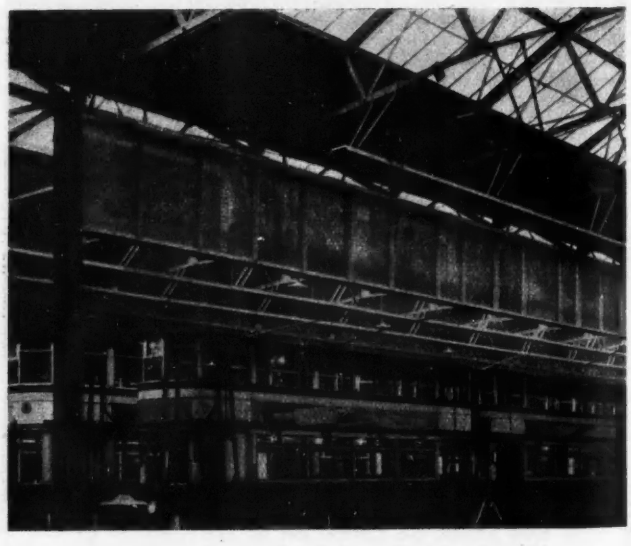
TRIALS have recently been completed on the Thames of the fast patrol launch, which we illustrate opposite, and which has been designed and built at the Hampton-on-Thames yard of John I. Thornycroft and Co., Ltd. Named "Sunga Marutham," the launch was ordered by the Crown Agents for the Colonies on behalf of the Collector of Customs, Ceylon, and her particular duties will be the detection and prevention of smuggling among the islands off Ceylon. To carry out such duties the boat has been equipped with a Decca Mk. 12 radar set which has a range from a few yards up to 20 miles.

To satisfy the requirements of speed and accommodation the launch has been built with a length of 58ft by 12ft 6in beam, and has a draught of 3ft 6in, and is powered by two Thornycroft-Rover "Meteorite" diesel engines. Each engine is capable of developing a maximum of 275 b.h.p. at 2300 r.p.m., and has a continuous output of 215 b.h.p. at 2100 r.p.m. giving the launch a speed of 20 knots and 19 knots respectively. A hard chine form has been adopted with a transom stern and a cut-away keel, and the hull is diagonally planked with a double skin of teak laid over closely spaced steamed American elm timbers and copper fastened. The underwater part of the hull is protected from marine borers by a sheathing of Muntz metal.

The general arrangement of the launch provides comfortable accommodation for the crew with adequate ventilation. There is an open bridge, having all-round vision, on which is mounted the steering wheel and engine controls, while behind the helmsman there is a standard compass fitted on a pedestal. The bridge space has raised side bulwarks extending aft and has a portable awning. A door to port gives access, down a short ladder, to the chart room, in which is fitted, together with other equipment, a 12in Decca radar display screen. Further for'ard, another door opens on to steps leading down to a lobby which has a toilet to port and a galley to starboard. Forward of the galley is the crew space which has locker seats, pipe berths, hanging spaces, a hinged table and a



Multi-Burner Heating Unit



Aluminium Roof Girder at a Birmingham Transport Depot

Patrol Launch "Sunga Marutham"

vertical ladder leading to an escape hatch on the fore deck.

Aft of the engine room is the officers' cabin, which has a raised roof and is fitted with Dunlopillo settee berths, lockers, wardrobe and sideboard, and at the forward end is a toilet to port, and the deck may be reached from the cabin by means of a ladder forward or an escape hatch aft. Right aft is the aft peak, which houses the steering gear for the twin rudders and two rubber bonded fuel tanks, each having a capacity of 200 gallons. There is a fresh water tank holding 50 gallons under the floor of the chart room.

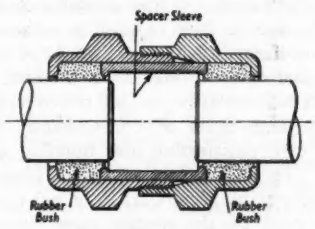
A door in the aft bulkhead of the chart room and another in the forward bulkhead of the officers' cabin give access to the engine room, so that it is possible to move from one end of the launch to the other without having to go on deck. The mast, arranged to starboard, can be hinged down and the radar mast has been designed so that it can be hinged down without having to break the electrical connections. Other equipment includes a searchlight, two C.Q.R. anchors, a Clifford and Snell loud hailer, life rafts stowed in the cabin roof, and bullet-proof mattresses for the chart room.

The engine room, which is well ventilated, provides ample space for the two Thornycroft-Rover "Meteorite" diesel engines, mounted on flexible mountings, which are fitted with reverse gears and drive through a 2 : 1 reducing gear. Aft of the port engine is a control panel and a mechanic's seat, while batteries are stowed to port and starboard. Each engine has eight cylinders, having a bore and stroke of 5·4in by 6in respectively, and arranged in two banks in 60 deg. vee formation. Cooling is effected by a closed circuit fresh water system in association with internal heat exchangers. Two pumps are fitted, a centrifugal fresh water pump delivers the cooling water to the cylinder jackets, and a large slow-speed gear pump delivers sea-water to the heat exchanger. The exhaust system is of the water injection pattern, with a flexible reinforced rubber piping leading aft to the transom. For lighting and the charging of batteries there is a 1kW Stuart Turner diesel generating set, located aft and to starboard, is fitted with an auxiliary dynamo for use with the radar equipment. Control of the engines is by means of a Thornycroft combined single control operated by the helmsman from the bridge.

Small Shaft Couplings

A RANGE of shaft couplings of simple design, known under the trade name "Torflex" and made by Howard Clayton Wright, Ltd., of Wellesbourne, Warwickshire, has been extended to include shafts between ¼in and 1¾in diameter. These couplings are quick and easy to apply and their design permits a degree of angular and parallel misalignment whilst giving a cushioned drive and electrical insulation between the shafts.

The design of a coupling can clearly be seen in the drawing we reproduce below. It consists of two caps with male and female threads, which fit freely over the shaft ends. Within each cap a rubber bush is enclosed and on assembly a spacer sleeve is inserted in the caps between these bushes. As the caps are screwed together the sleeve compresses the rubber bushes, which close inwards to grip the shaft



Small Shaft Coupling

ends firmly and at the same time a small amount of rubber is squeezed out of the end holes in the caps to eliminate any metal-to-metal contact. The caps are made with right or left-handed threads to adapt them for either direction of shaft rotation.

The smallest couplings, for ¼in diameter shafts, transmit a maximum torque of 4in-lb and the largest couplings, for 1¾in shafts, a maximum torque of 825 in-lb. If it is required to couple shafts of different diameters two different sized rubber bushes can readily be used.

A Mechanical Remote Control System

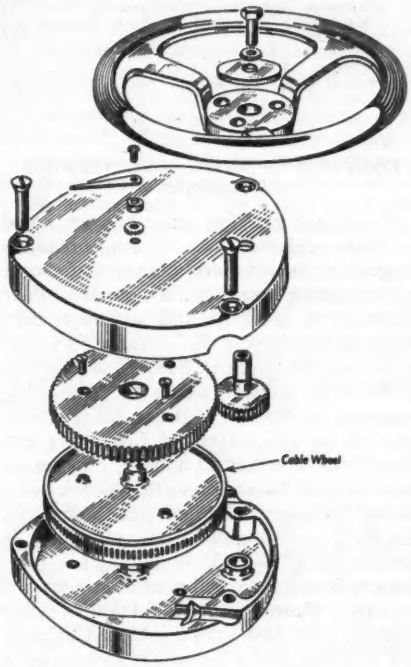
A SYSTEM of mechanical remote-control which has been developed by Teleflex Products, Ltd., of Chadwell Heath, Essex, is designed to provide an effective means of transmitting rotary or straight-line motion to normally inaccessible or widely spaced units. The flexible nature of the control system and the number of standard transmitter and receiver units available for different purposes adapt it for a very wide field of industrial application, particularly where modifications to existing plant layout cannot readily be made to install mechanical controls.

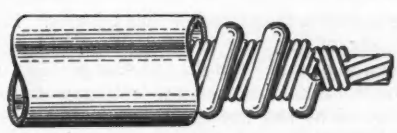
The control gear makes use of the design of transmission cable developed by the firm and used in its conveyor systems. This cable, a section of which can be seen in one of the diagrams on this page, is built up from a multi-strand high-tensile steel wire core, over which other layers of wire are wound to form a continuous helical worm or thread. The cable is mounted in a closely fitting tube, through which it can slide freely, but cannot "kink" under load.

At the transmission end of the control unit the cable is maintained in engagement with a hobbed cable wheel. The rotary movement imparted to the cable by turning this wheel at the operating end of an installation is transmitted to the unit to be actuated by a similar cable wheel if a rotary motion is required, or to a fork and swivel if a sliding motion is called for.

The cable can be operated both in tension or compression and has a high degree of flexibility so that the tubular conduit in which it is enclosed can be bent to follow the most suitable route between the control and operating units. To operate flexibly mounted devices, the conduit can be fitted at the end with a short flexible section.

The simple design of a typical geared operating unit for this control system can be seen in the diagram we reproduce. It consists essentially of a die-cast case in which a cable wheel is attached to a large gear wheel rotated through a smaller gear by a hand wheel. Holes formed in





Arrangement of Geared Operating Unit and Cable

the sides of the case are designed to lock on the outer conduit and the cable itself passes round the cable wheel and is held in engagement by contact with the case. Rotation of the cable wheel through the hand wheel serves to draw or push the cable along the conduit according to the nature of the duty. These operating units are available in a number of forms to suit different classes of work, and the driven units are generally built to work on the same principle in reverse to operate racks, levers, screws, wheels, &c. Various forms of box units are made for fitting into a line for transmitting power intermediate points, operating at right angles to the main line, reversing the direction of power transmission, &c.

The cables are supplied in two sizes, ½in and ⅝in. A run of ½in line can be turned through 90 deg. on a 12in radius and a ⅝in on a 7in radius. A straight transmission line of ⅝in cable, 100ft long, fitted in brass conduit, is capable of transmitting a load of 172 lb in tension and 95 lb in compression. A similar line with one 90 deg. bend can transmit a load of 130 lb in tension and 60 lb in compression, whilst with two 90 deg. bends the respective loads are 100 lb tension and 40 lb in compression.

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COMPETITVE CIVIL ENGINEERING DESIGN

During the past few years we have noted in these columns on various occasions suggestions which have been put forward by consulting engineers to improve their methods of working and to meet contemporary problems. For instance, in a note in our issue last week we outlined some of the problems at present facing the consulting engineer, as seen by Sir Bruce White, chairman of the Association of Consulting Engineers, and commented upon by him during the course of his speech at the Association's annual dinner. One of the difficulties hindering consultants from obtaining a greater share of work abroad, it has been argued, is the inflexibility of their codes of practice. Recently the Institution of Civil Engineers adopted a rule intended to meet this criticism, that a consultant seeking work in a Commonwealth country would be entitled to adopt the rules of a responsible engineering institution in that country. The easing of etiquette in other ways has also been suggested. But the overseas problem of the consultant is not the only one to be affected by this line of argument, for it has also been suggested that changes could be made in the organisation of civil engineering work in this country.

Under the contracting system as it is now practised in this country, the scope for competition, and the economy which results from it, is nowadays rather limited. A design is prepared with its corresponding bill of quantities, upon which a contractor bases his tender. But labour rates are standardised and universally applicable, materials are bought for standard costs, and generally speaking, rates of hire for constructional plant are standardised as well. The contractor is therefore left only with the comparatively restricted field, covering the organisation and methods used in the construction of the consultant's design, in which to show his skill in carrying out the work efficiently and cheaply. How much greater would his opportunity be, it is argued, if his tender were linked to a design the details of which were to his own choosing? He would then be able to use, perhaps, some medium of construction in which he had particular skill or experience, or the design could be evolved so that it suited each stage of the constructional method which he favoured and the particular plant he had available. By this method, it is thought, the design would contribute directly to the economy of the tender, and a true comparison would be obtained between the costs of the different designs submitted. Furthermore, the suggestion that consultants design with an eye to their reputation rather than to the economy of the work, would be shown to be unfounded. Here is a method, it is argued, which shows promise of reducing the present high costs of construction of the many civil engineering and building works which are so urgently needed. There are doubtless many arguments to be put forward in support of the system now favoured, where the independent position of the consultant is one of great strength, and where there are many years of successful experience and practice upon which to draw. The interests of the client are well looked after, the contractor is paid fairly, and, with very few exceptions, the system works smoothly and efficiently. Moreover, it is, in fact, the consultant's practice to prepare alternative proposals and to estimate which of them is the best, so that many consultants would question whether there was any advantage in designs other than their own.

But, we wonder, is it not possible to combine the best of both these systems? The competitive design is, fairly clearly, not suitable for all new projects, and, where a competitive design is not called for, the virtues of an independent consultant need not be dispensed with, although he would no longer carry out the design in detail. A recent example where this procedure was adopted apparently with success, is that of the prestressed concrete hangars and maintenance base of the British European Airways at London Airport. Another alternative involves the preparation of an "official" design to the given specification, but allows the contractor to submit an alternative design if he believes he can do so to advantage. We ourselves are not in a position to be dogmatic about the costs of civil engineering works. Should we ever be so indelicate as to inquire in too much detail how much a certain structure or project cost to construct, the answer is generally very guarded. A frequent reply, whether it be steel, timber, reinforced concrete, prestressed concrete, aluminium, or any other material that is being employed, is that "this method is 5 per cent cheaper than any other." Probably that 5 per cent lies as much with the special skill and experience of the exponents of the particular material in question as with the merit of the material itself. A competitive design would, we think, take all these factors into account; wisely applied, it might result in no little economy, resulting in cheaper work without sacrifice of efficiency or strength.

NUCLEAR ENERGY IN WAR

It is doubtful whether the public realises the great change that has come in the course of a few years in the ways in which nuclear energy can be used for warlike purposes. When, in 1945, the American Smyth Report was issued, on both sides of the Atlantic, one was led to believe that the smallest variety of atomic bomb would prove as big a load as a large aeroplane of that day could carry on operational missions. Now one reads of such bombs being small enough to be carried on fighter aircraft, and even of shells with atomic warheads being fired by mobile artillery. Thus there has come about a very striking change; for it means that the atomic explosive is no longer solely of use for large-scale warlike action, but that it may prove a potent defence against aggressive armies, and possibly when fully developed become an efficient keeper of world peace. Whether we in the West are already well on the way to this striking development or not, it is a portent that there is planned to take place in this present year a Service exercise to consider the possible future use of such weapons, at which Commonwealth Forces will be represented.

There is in some persons a certain feeling of revulsion towards any novel means of making war; it happened when the crossbow was invented, when gunpowder was first introduced, and now when a means for the release of nuclear energy has been discovered. Such reactions, though natural in sensitive people, need to be carefully weighed and considered before they are treated as being of importance when national issues of great consequence are at stake. Unlike earlier forms of military devices, nuclear energy has a dual quality in that it may be employed in two very different ways, as an explosive weapon or as a fuel for propulsion. Its advantage as an explosive is that its shattering effect is so intense, and when used as a consumable fuel it has the merit of being almost weightless. No one will object on moral ground to its use as a fuel; objection has, however, been raised to its use as an explosive on the ground of its devastating capacity, whereas whether the use of any given weapon can be said to be "immoral" or not must depend not upon either its novelty or its high efficiency, but upon the specific purpose for which it is used. This

point was made very clearly in a recent issue of the *Atomic Scientists News*, when Dr. J. L. Michiels, the General Secretary of the British Atomic Scientists' Association, reminded his fellow countrymen that mass attacks on a city are as immoral with ordinary bombs as with atomic ones.

The widespread damage done by the two atomic bombs in the attacks on Hiroshima and Nagasaki at the close of the second world war is fully known to the general public, but do they realise as fully how much damage was done in Hamburg, for instance, by ordinary incendiary bombs earlier in the same war ? In the U.S. Strategic Bombing Survey of September, 1945, it is stated that during that attack on Hamburg the fire-fighting defence was entirely defeated, and that as the flames spread there arose such an intense fire storm that in a short time the temperature reached the ignition point for all combustibles and the entire area was ablaze. What is described as a complete burn-out occurred and no trace of combustible materials remained ; only after two days were the areas cool enough to approach. Mass attacks by incendiary bombs can be not only as devastating as those by atomic bombs, but are likely to be even more destructive to the civil population, since they are far less capable of being accurately aimed. The smaller the number of bomb-aimers required in any operation the greater the accuracy of the aim.

Such reflections as these on the possible, and even probable, use of nuclear energy in another war may to many be not unfamiliar, but they need to be more widely known, for if a third world war should unfortunately be set on foot by some ambitious power-seeker it will be unrealistic to expect that atomic explosives will not be used. Their very existence as one of the most potent of all forms of defence against the attacking aggressor must ensure that. It is well, therefore, that their more effective forms of use should be fully studied by the military authorities of the Western Allies.

Literature

Marine Diesel Engines. By C. C. POUNDER. London : George Newnes, Ltd., Southampton Street, W.C.2. Price 35s.

It is related of Professor Agassiz that when asked by a New England mutual improvement society to give them a lecture on fishes, he replied that it was a thing impossible. He would, however, be pleased to deliver " a course of lectures on a fish scale." Though the title *Marine Diesel Engines* may suggest a large treatise, Mr. Pounder modestly explains that the volume was written with " no purpose other than to assist those young marine engineers whose aim it is to understand some of the machines by which the ships of commerce plough their way through the seas *nec remis nec velis*." It would certainly be impossible to use a more effective method of tuition than that employed by the author in the compilation of this book, its *corpus* consisting of six chapters describing and illustrating the machinery built by six representative manufacturers of marine diesel engines. So that the features of the various types can be set forth with the utmost clarity and authenticity, the descriptive matter has been prepared by engineers prominently associated with the individual firms. The creation of such a symposium is very encouraging to those who look for technical collaboration at an international level, and Mr. Pounder has thus stamped the book with a universal flavour which enhances its value.

Long ago, at a time when steam engines were built only in Great Britain, James Watt received grant of a patent in which he (or most probably his able assistant, John Southern) illustrated certain alternative devices whereby the motion of the engine could be communicated " without using the great chains and arches commonly fixed to the working beams of the engines for that purpose." We were reminded of these eighteenth century designs when looking at the multitude of drawings (there are as many as 230) reproduced in Mr. Pounder's book. How instructive it is to compare, for example, pages 29, 166, 249 and 282, whereon are set forth cylinder cover designs used, respectively, by British Polar, Harland and Wolff, M.A.N. and Sulzer Brothers. This is just one example of how a compilation built up in this way lends itself to informative reference. Incidentally, examination of the illustrations emphasises the wide diversity existing in the design of such pieces as cylinder covers and we are shown, indeed, examples where the cylinder cover is dispensed with altogether. The young (or old) marine engineer will find, in this book, many short cuts enabling him to quickly compare the ideas, on specific components, of eminent marine engine building firms. Pistons, fuel injection equipment, manœuvring and reversing gear, scavenging pumps and blowers, bed-plates, casings and other elements are spread before the reader not only copiously and accurately but in something like anatomical order and with canonical authority. The reader can browse among fuel injection pumps by just turning over the well-illustrated pages whereon are shown the fuel pumps and fuel valves standard on British Polar, Doxford, Harland and Wolff, M.A.N., Sulzer and Werkspoor engines. A book of this nature is either orderly or slipshod and when we read the orderly kind—of which Mr. Pounder's present volume is a good example—we acquire a stronger aversion to those ill-sorted and incoherent compilations which are the bane of technical literature. Many engineers are specially interested in the controversy as to the merits of crosshead and trunk piston designs. On this the book before us illustrates and describes the practice of the most eminent designers of marine engines, and Mr. Pounder sums the matter up in the following words :—

" Marine engineers, in general, prefer crosshead to trunk designs of propelling engine. The practical basis of dislike is centred, not in the utilisation of the piston skirt as a guide, but in the use of gudgeon-pins. The contention is that after gudgeon-pins have once been removed they cease to be tight—but this must depend upon the design and manufacture of the gudgeon-pins. Floating gudgeon-pins are impracticable for large engines. The advantages of trunk engines are : lower first cost ; less weight ; some reduction in height. The disadvantages are : a substantially greater lubricating oil consumption ; sometimes—but by no means always—greater wear of pistons and cylinder liners. On balance, the disadvantages outweigh the advantages, because the lubricating oil cost alone more than offsets, for propelling engines, all the advantages of the trunk design. Trunk engines, therefore, are used only when crosshead designs are inapplicable."

It is certainly true that the gudgeon-pin (by which we mean circular gudgeon-pins mounted in bosses cast in large piston skirts) reminds one of that famous character in the *Pilgrim's Progress* who appeared " something more comely at a distance than at hand." Mr. Pounder and his collaborators have shown, in this book, various arrangements manifestly designed to minimise the distorting effect on a large trunk piston of the torque reactions of the connecting-rod. More than sixty years ago that great British engine designer, John Henry Hamilton, decided that if there must be gudgeon-pins they should be so fastened into the piston as to reduce, to the utmost, the possibility of piston distortion. Hence came the bolted-on piston-pin of which some representative modern examples are illustrated in Mr. Pounder's book. Hamilton's design of piston was used in gas engines before the diesel engine was ever heard of, and he retained it when he came to build direct-injection oil engines.

In a short review of this book it is impossible to cover more than a small area of the ground. A copious index sets forth the contents and he who would make himself familiar with the admirably illustrated text will find good grazing in all its sections. The book is full of readily accessible information and, while it is specifically intended for the marine engineer, the contents are of equal interest to those who have to deal with large stationary engines. In what may be called the interstices of his book, the author has stored much valuable information and advice. It is drawn from that long practical experience wherein the years teach much that the days never knew ; experience only reflected by those who, like Virgil (and Mr. Pounder), can say : " *Non ignara mali miseris succurrere disco.*"

SHORT NOTICES

The Measurement of Particle Size in Very Fine Powders. By H. E. Rose. Constable and Co. Price 9s.—This book, which is based on four public lectures given at King's College, London, is primarily devoted to a comprehensive description of the simpler techniques for measuring the size characteristics of fine powders within the size range 0·001mm to 0·06mm. The subject is presented in sufficient detail for a worker to be able to decide, on a logical basis, the best method of determining the size characteristics of any particular powder. The range of powders which come within the scope of the author's treatment is indicated by the references given in footnotes which refer to such diverse materials as cements, paints, pharmaceutical chemicals, soils and metal powders. Some discussion of recent developments in this field and the results of researches that are in progress are also included in a text which is freely illustrated by diagrams.

Dr. Rose is to be congratulated on writing a book which will prove of value to a wide circle of readers in many branches of industry and applied science.

BOOKS RECEIVED

Newnes Engineers' Reference Book. Fifth edition. Edited by F. J. Camm. London : George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 63s.

Radio Upkeep and Repairs. By Alfred T. Witts. Seventh edition. London : Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 12s. 6d.

Wind Tunnel Technique. By R. C. Pankhurst and D. W. Holder. London : Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 57s. 6d.

General Trade Mathematics. Second edition. By Edwin P. Van Leuvon. London : McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 32s. 6d.

Statistical Year Book of the World Power Conference, No. 6. Edited by Frederick Brown. London: The Central Office of the World Power Conference, 201-2, Grand Buildings, Trafalgar Square, W.C.2. Price 35s.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

LIBRARY SERVICE FOR INDUSTRY

SIR,—Mr. Fullman and Mr. A. R. Smith have given excellent replies to parts of Mr. Rider's article in your issue of February 13th, but in view of Mr. Rider's further letter (March 27th), I hope you will allow me to add a few points to the discussion.

The arguments concerning the relative capabilities and fields of work of librarians and information officers have been increasingly discussed in the last few years, and not without acrimony. Several librarians, though perhaps not Mr. Rider, maintain that the tasks are entirely within the grasp of the librarians, or, at least, of the progressive graduate librarians, who, though few in number now, are expected to increase rapidly in the future. In industry, however, with its predominant technological basis, the understanding of the need for wide general scientific and technical knowledge for information work has led to the appointment, in most cases, of information officers drawn from the ranks of scientists. It must be realised that such information officers are essentially research scientists who happen to have specialised in the problems of information. Such men and women are an integral part of a research or works team ; they do, of course, use libraries and other sources of information extensively, but contacts among their scientific colleagues, to whom they speak on equal terms, are equally important.

Wide scientific reading and, if possible, practical research and works experience, are essential to the job. An experienced information officer of this kind can not only answer many simpler inquiries almost out of his head (which is much quicker than a search by a less informed person), but he can deal more efficiently with the types of inquiries which have no complete answer or which are of an indefinite, research nature. In the active dissemination of information (in advance of inquiry), he can have an insight into the needs of the research worker or works technician which greatly aids the provision of the right information to the right man at the right time. An abstracts bulletin or the circulation of periodicals is a much less direct process. The information officer is in a position to make fruitful suggestions, backed, of course, by the literature, from outlying fields which might never be covered by a regular bulletin. Although information officers are frequently called upon to take charge of small libraries in industry, they are not, and have no need to be, librarians ; they are only experienced users of libraries.

On the other hand, if a librarian has scientific or technical qualifications, and is the right progressive, research-minded type of person, there is no reason why he should not be able to carry out a great deal of useful information work. But let him not imagine that he is then still just a librarian. He will change in the process ; he will find that a new outlook and new techniques are necessary. Although there are at present individuals undertaking work at all the various stages possible between that of librarians who are only custodians and that of information officers who have no library at all (Mr. Smith's intelligence work), the information officer is rapidly growing away from the librarian to become a member of a new profession, with further interests in such expanding fields as technical liaison, public relations, publicity, &c. This profession is becoming vital for industrial progress.

What is needed is not dissension between librarians and information officers, but co-operation. The librarian need not fear that he will lose status by the growth of the status of information officers. The libraries are ever more essential, and the answering of the more straightforward factual inquiries, which the librarians can well handle, is indeed a most useful service to the public and less specialised inquirers. By attempting, however, to minimise or belittle the position of the information officer, the librarian will only earn the laughter of enlightened technical management. It will show that the librarian has failed to understand the real needs of research and technology in industry.

J. FARRADANE,
Scientific Information Officer,
Tate and Lyle Research Laboratories.

Keston, Kent,
March 31st.

UNBALANCE

SIR,—In your issue of March 20th under the heading of " Less Talk and More Effort," any thinking person would agree that, unless there is increased effort, people cannot consume more and enjoy a higher standard of living. On the other hand, it by no means follows that because the capacity to produce is increased more will, in fact, be purchased and enjoyed. If this were not true there would not be " a mass of sellers seeking to find outlets for their greatly augmented production," as observed by the author in question.

The law of supply and demand is simple only up to a point. When the market has more to offer than the buyers can purchase prices fall, regardless of the cost of efficient producers, unless artificial devices are introduced by capital and labour, such as price pegging and restrictions of output. Governments indulge in other methods to combat the so-called " buyers' market " by maintaining high tariffs or imposing import restrictions of one kind and another. Hence the fear that a " trade recession " or " buyers' market " in the United States would restrict still further the export of goods and services into that country. Ask any American whether he likes to import cheap or expensive and he will generally tell you he does not want it either way !

It is, of course, readily understandable after a world war, in which there has been the combined effect of a shortage of practically everything and a great increase in the amount of money in circulation, that there is bound to be a " sellers' market "—for a time. However, when nations such as the United States and Canada are able to double their output in about twelve years it is not surprising, with present economic thinking, that the market becomes unbalanced in the opposite direction—this time with more sellers than buyers.

In the same issue you quote the Economic Survey of Europe, reporting on the post-war position, which says " for the last eighteen months the economy of Western Europe has lapsed into stagnation, demand has shrunk and profit margins have become lower." No wonder, under the present way of thinking !

Only this last week the British Productivity Council, comprising some of the best representative brains in industry, decided to set up productivity teams all over the country, comprising management, technicians and workshop staff, in order to stimulate productivity at every level. To increase the capacity of the sellers is, however, only half the problem. What is also needed is a clear realisation that mines, factories and fields produce goods, whether capital or consumption, but they do not create the means of buying these things, namely, money in its various forms. Hence the other half of the problem is to increase the capacity of the buyers such that there is neither a buyers' nor a sellers' market.

When it is realised that the overall ability to buy should keep in step with the overall ability to produce, many of the present-day troubles, both national and international, will disappear. Restriction of output by capital and labour, at present costing the nation perhaps 10 to 15 per cent of the total output, will become a thing of the past. The taxing of the efficient to subsidise the inefficient will automatically decrease. World trade will have a chance to expand. Peace would be welcomed instead of being regarded as the forerunner of economic depression.

ANTONY VICKERS

Isleworth, March 24th.

DIMENSIONS ON DRAWINGS

SIR,—I was interested in the views of several correspondents on drawings and dimensions. The engineering drawing is the " language " of the professional engineer who wants to get something made, in the same way that standard musical notation is the " language " of the composer who wishes an audience to hear a great symphony. Neither an engineering drawing, nor a piece of music script, are of any value in themselves ; they are only useful as a means to completing the engineering process and the performance of music, respectively.

In the world of music, the standard notation makes it possible to hear a performance of Beethoven's seventh symphony interpreted exactly as Beethoven intended it to be, by any orchestra in almost any part of the world.

In a parallel way and by the natural evolution of things, there is good reason to believe that in the course of time the " language " of engineering drawings will be more completely standardised, to the lasting benefit of everybody concerned. There can be no doubt at all about the economy in time and cost which would result from such standardisation.

E. W. J. TRILLO

Cheltenham, March 21st.

RAILWAY MOTIVE POWER FUEL COSTS

SIR,—The figures of railway motive power fuel costs which you quote from Mr. Riddles in your issue of February 27th are, as you say, interesting, but before accepting them as a legitimate comparison between the various types of traction, engineers will want to know a good deal more about the basis of their compilation.

The locomotives were not tested over the same routes or on similar duties. Although there is a tolerable similarity between the Waterloo-Exeter and Paddington-Plymouth runs, at any rate, as regards energy used in acceleration as a proportion of the whole, the Victoria-Newhaven route, with its many speed restrictions and tight sectional timings, is a totally different concern.

The first question to be asked, therefore, is whether any allowance has been made in the figure quoted for the energy lost in accelerating the electric locomotive itself away from these speed restrictions.

It is also necessary to know what prices were used for the fuels as delivered on to the locomotives, and in the case of the steam locomotive, whether an addition was made for the cost of water and ash disposal. Were standby and lighting-up losses also allowed for ?

The comparison between the prices of coal delivered on to the locomotive tender and into the power station bunkers would also be interesting in view of the past predilection on the part of steam supporters to use pit-head prices in assessing their costs, a practice which is hardly justifiable in face of the many complaints from railway commercial men that public mineral traffic is handled on a no-profit basis, which can only mean that it costs a railway as much to move its own coal as it would that for anyone else.

The Railway Executive has often proclaimed its intention to keep nothing back from its proprietors and Mr. Riddles himself has frequently alluded to his own impartiality in these matters. I therefore look forward to an early clarification of these questions.

M. R. THOMAS

London, N.W.6, March 30th.

The Institution of Naval Architects

ANNUAL SPRING MEETING

No. II—(*Continued from page* 493, *April* 3*rd*)

ON Thursday morning, March 26th, the meeting opened with a paper entitled :—

LARGE DRY DOCKS

By E. LESLIE CHAMPNESS, M.B.E., M.Sc.

SUMMARY

The papers read before the Institution of Civil Engineers in 1948 on the subject of the large dry docks at Sydney and Cape Town are recalled and the paper discusses the trend of proportions of length to beam of merchant ships and the naval requirements of the future. The range of the length to beam ratio is given and illustrated graphically, and it is noted that draught is limited by the depth of the terminal facilities. Curves of widths of dry docks are shown and attendant facilities are listed, while the general position is reviewed. The development of the oil tanker is stressed as a governing factor and trends in size are shown graphically and in a tabular statement, while the declining position of the United Kingdom in the matter of dry docks is pointed out and linked with the unfavourable budget financial policy. Economic considerations are related to present-day expansion and possible earnings and it is suggested that constructional costs may be cut by improved civil engineering technique. A drawing shows a double-ended dry dock incorporating schemes for intermediate gates to solve the problem of maximum usage.

DISCUSSION

Sir Stanley Goodall : When a new dry dock is contemplated, the civil, mechanical engineering and financial problems press the naval architect to accept the minimum width considered reasonable at the time rather than a width that may be required twenty or forty years hence. It must be borne in mind that once a dry dock is built it is generally possible to lengthen it, but it is practically impossible to increase its breadth.

I take exception to the statement that "the proportions of docks proposed in Fig. 1 should not, therefore, be overtaken in the future by developments in ship proportions such as have occurred over the past forty years." How often have similar forecasts been made and invariably proved to be false ! For example, the large dry docks at Rosyth and Portsmouth, completed just at the time of the outbreak of the first world war have now proved to be inadequate in width. I am not thinking of battleships ; I am thinking of a remark made by the First Sea Lord to the effect that "at present naval shipbuilding is confined to those small units in which the Royal Navy is so deficient. But the time will surely come when we must consider replacing those larger types built during the recent war." I think Mr. Champness has some misgiving because on the subject of width he takes refuge in the atomic age and says that the fleet of the future may consist of smaller units.

I should like Mr. Champness to show in the lower part of Fig. 1 the length and width of the Panama Canal locks, because I remember Sir Eustace D'Eyncourt saying that it should be possible to dock in this country any vessel, naval or mercantile, which could just squeeze through that canal.

I take exception to the criterion of length overall divided by 10 plus 20ft for the beam of merchant ships, for I think that if a line $L/10+30$ were drawn in the upper part of Fig. 1 we should have a more realistic picture and it would appear that there is practically no difference between the dock width desirable for merchant ships and naval vessels.

Nothing has been said of the strategical side of this subject. But if you look at the lower part of Fig. 1 and if you draw the curve of dry dock width in its correct position, the situation in regard to docking facilities in this country is shown to be just awful. If we drew a line from north of Liverpool to the mouth of the Thames we should see that all the large dry docks are south of that line. It seems dreadful that our large shipbuilding centres can build ships of a certain size but cannot complete them.

Mr. M. G. J. McHaffie : The lower part of Fig. 1 shows that all but six of the United Kingdom mercantile dry docks lie below the curve of the line of ideal entrance width for present-day lengths. In accepting this, it should be borne in mind that the curve is a purely arbitrary one.

I agree with the view that we tend to adopt a smaller entrance width than an anticipation of the beam of future ships would suggest to be prudent, but it should not be overlooked that any dock authority seeks the best advice before deciding on the width of any large dry dock. If the shipowners and their naval architects spring a surprise, the culpability cannot be laid on the shoulders of the dock authority. One such instance is that of the No. 6 dry dock at Southampton, which had to be widened only five years after it was built. Then came the "Majestic," having a beam of 100ft, and she could not enter the dock at all, so that the Southern Railway installed the 60,000-ton floating dock at Southampton. It was capable of lifting the largest liners then afloat—the "Berengaria," "Majestic" and "Leviathan"—and was designed so that an additional section could be added to accommodate larger ships in the future. However, it could not lift the "Queen Mary," and so it was sold and the King George V dry dock was built instead.

In dealing with economic considerations the author looks to civil engineers for a technique and plant which would reduce the present heavy cost of construction, particularly that of excavation and disposal. The excavation of the spoil between the side walls is always taken out by dragline. This would not be economical for the side wall excavation, the usual practice being for the side wall excavation to be taken out in trench. Tendering for public works by civil engineering contractors is highly competitive, and they may be relied upon to adopt the cheapest and speediest methods in carrying out their work.

Mr. B. P. Ingamells : I do not think that in times of emergency the Admiralty becomes a major user of private facilities, for at no time during the last war was the Admiralty a major user of private facilities. Although both sides went short of facilities at different times, that fact merely stresses the shortage of large dry docks.

In the list of attendant facilities, which at any dry dock play a part in its efficiency, I commend the fitting of lifts to the dock bottom, and it is interesting that these are being incorporated in the only large dock at present under construction in the United Kingdom. Another item which has received scant attention in the past is a sufficient water supply for the testing of tanks, which is imperative under modern tank testing conditions and the need for the quick turn-round of ships.

I agree with the large increase in the number of ships of large beam, but think that the beam categories have not gone low enough, for the "Liberty" ship, with a beam of 57ft, has become a major factor in judging dry dock facilities.

The proposal for a double-entry dock laid alongside is most ingenious and has much in its favour. The major disadvantage would be the need for an extensive river frontage, which is a rare acquisition in this country. I agree with the figure quoted in the paper, of from £1,000,000 to £2,000,000, as the price of a large modern dry dock. I should like to learn if any estimates have been obtained for the proposed double-entry dock and ship-repairing yard, and suggest that the cost of such a plant must be about £10,000,000 to £15,000,000. I prefer the greater realism of the author's plea to the civil engineers for improvements in methods of construction. Already at North Shields there are indications of such possibilities ; let us hope there will be further improvements which will reduce costs and time of construction, so making it possible for us to have the dry docks the country must have if we are to maintain our lead in the ship-repairing industry of the world.

Mr. D. Rae : I am glad the author has referred to a very important commercial aspect of this whole question of providing adequate large dry dock facilities in this country. The existing depreciation allowances applied to dry docks are totally inadequate and completely fail to recognise the incidence of obsolescence. Dry docks are treated for depreciation purposes on the same basis as buildings and the ship repairing industry contends that this is wrong and that dry docks should be treated as items of heavy industrial plant. The Dry Dock Owners' and Repairers' Central Council has been pursuing this question consistently since 1949 and it is regrettable that the powers-that-be seem so reluctant to take speedy action. Every year sees a growth in the number of large vessels and more large dry docks are vitally necessary if we are to tackle adequately the services required by modern merchant fleets. To have too few dry docks of adequate size and capacity for handling modern ships is to suffer from a very real deficiency in our national defences.

The industry's case is that as regards expenditure on new dry dock construction or modernisations of existing dry docks the annual allowances should be on a scale to write off the whole of the expenditure within the period of the anticipated useful life of the asset, which for large dry docks to-day has been put at an average of twenty-five years. We ask that the existing law be amended to permit the annual allowances in relation to capital expenditure on dry docks to be negotiated by the Commissioners of Inland Revenue and bodies representative of dry dock owners. I have referred to writing off the *whole* of the expenditure because an anomaly in existing legislation is that, while depreciation is allowed on the dry dock itself, the allowance does not apply to the cost of excavation. More encouragement by way of taxation reliefs is given in other countries and it is essential that ship repairing firms in this country should not be handicapped in relation to their overseas competitors by being deprived of the means of providing all the modern facilities required. There is also the anomaly that floating docks are treated as plant for depreciation purposes, whereas dry docks are not—a position which is patently absurd.

Mr. H. S. Pengelly : Ever since the first world war, British large warships have been restricted in beam by the docking facilities available, and German large

ships have been restricted in draught by the depth of water in the Kiel Canal. In 1951 the occupancy of docks capable of docking Liberty ships and above had reached a practical limit of about 80 per cent average. The number of ships of 57ft beam and over on the U.K. Register has increased from just over 800 in 1938 to just over 1300 in 1951 and nearly 1400 to-day, and indications are that this increase will continue. There is already a need for some increase in the number of large dry docks.

It does seem that a capital asset costing millions should not remain idle. With a five-day week and restricted hours of work, the effective occupancy of dry docks may be as low as 20 per cent. Double shift working and higher dock dues might provide a solution welcome to both dock owners and ship owners.

Mr. J. Guthrie Brown : There is no doubt that the dry docks constructed in this country and elsewhere are too narrow in relation to their length ; but since the draught is governed by the limitations of dredged channels, the naval architect has to increase the size of vessels mainly in length and beam.

Normally it is relatively simple to lengthen an existing dry dock, but its widening and deepening is much more expensive and difficult. It is therefore essential to provide ample width in designing any new dock.

The dry dock under consideration for the Republic of India is being designed with a proportion of width equal to $L/10+30$, which appears adequate for requirements up to the cruiser class ; and it also allows destroyers to be docked abreast.

The reference to two or three years as the time required for constructing a large dry dock is optimistic ; my estimate is at present nearer four years as a minimum.

Means of reducing the cost of dry docks are not easy and the excavation is certainly not the critical factor. Costs are largely tied up with the site and foundation conditions and the cofferdam, and, of course, the concrete in the walls and floor are the two major items. One of the factors affecting the increased cost of dry docks is indicated by the impressive list of services which are necessary in the modern dry dock. Therefore, the increasing cost of dry docks is not necessarily the fault of the civil engineer ; the naval architect has some responsibility in respect of the demand for a multiplicity of services at and around the dock.

Mr. J. Hunter : The dry docking facilities in this country, so far as the larger ships are concerned, are now totally inadequate. In 1939 the total number of tankers in the world of 15,000 tons and over was 168, but by 1952 there were 279 tankers of 18,000 tons deadweight and over, and by 1958 there will be 774 of these bigger tankers afloat. From the dry dock point of view, whereas in 1939 there were eighteen private dry docks in this country capable of taking the general run of tankers, i.e. from 15,000 to 18,000 tons deadweight, which numbered 129, there are to-day only three docks capable of taking the general run of large tankers, i.e from 22,000 to 32,000 tons deadweight, and this number will be 395 by 1958.

When contemplating the dimensions for a new large dock the right dimensions cannot be obtained from a curve of means ; the correct criterion is the maximum size existing and foreseeable.

The breadth of the dock entrance should for preference exceed that of the ship by at least 3ft for lengths up to 800ft, and probably more than that beyond this size, and for ships from 700ft to 800ft overall the breadth of a dry dock to-day should be in the region of $L/10+30$.

Mr. A. Logan : Dry dock construction in the U.K. has definitely not been keeping pace with the increase in the size of ships, and it is noteworthy that no public authority has undertaken any new construction or enlargement programme in recent years.

Of some 370 tankers of 21,000–40,000 tons deadweight, either in service or building throughout the world, about 180 are owned by European countries, the balance belonging to American owners or companies whose interests are mainly in the U.S.A. The new buildings, which number about 240, are mainly scheduled for delivery between now and 1958. It might be assumed, therefore, that 200 vessels per year is a fair assessment for docking in Europe, of which possibly twenty could be dry docked at a time.

Whilst a number of the dry docks in the U.K. and Europe could undoubtedly accommodate them, nevertheless most appear to have very little working space, which is very important when it comes to shell plating repairs, renewals, &c. After making appropriate allowance for working space, it would appear that there are about thirty dry docks in Europe suitable for 21,000–25,000 tons deadweight tankers, decreasing to eighteen for 26,000–32,000 tonners, and eleven for ships of approximately 40,000 tons.

The second paper to be discussed on Thursday morning, March 26th, was :

THE MOTION OF AN AIRCRAFT CARRIER AT SEA IN RELATION TO THE OPERATION OF NAVAL AIRCRAFT

By J. L. Bartlett, C.B.E., R.C.N.C.

Summary

The paper refers to earlier estimates made of the maximum vertical movements, velocities and accelerations in various parts of the flight deck of an aircraft carrier under conditions representing the limit of the possible operation of aircraft. The various assumptions made at the time, the investigations analysed, the data used and the results obtained are surveyed. The general relationship between wind and waves is considered, such as wind speed related to maximum wave height and length, together with the steepness of waves, confused seas and the probability of meeting waves of specific heights. Ship motions and the effect of damping are investigated and some conclusions given, while the results of experiments concerning the loss of speed in waves are shown graphically. Other tests touched upon include aircraft carrier model experiments and the results are plotted to indicate pitch, heave and flight movements. The rolling velocity and acceleration of several ships are recorded and the limiting conditions for operating aircraft in an aircraft carrier are estimated.

Discussion

Rear-Admiral C. John: All who have commanded aircraft carriers have experienced a sense of frustration when it has been decided that the motion of the ship is too great to allow the operation of aircraft in safety. We are able to make considerable use of the steady period for the reception of aircraft on deck by a measure of patience and good timing. I foresee that with jet aircraft we may be denied the use of the steady period because their high fuel consumption is such that they cannot wait for the ship to become steady.

Aircraft carrier motion clearly has a direct bearing on the design and strength factors of the aircraft undercarriage, which we are anxious to reduce in size and weight. Therefore the study of aircraft carrier motion should go hand in hand with the study of aircraft approach and landing characteristics.

The technique of landing on the deck of a carrier is about to undergo a considerable change, combining faster approach speeds, a constant angle of approach, angled decks, and the substitution of mechanical for human deck-landing aids. All these factors lead to a more accurate arrival relative to a point on the deck, and this point looks like being further forward than hitherto, and consequently closer to the null point.

Captain H. A. Traill: So long as the present characteristics of aircraft remain, the ship movement will impose limitations on their operation. I do not quite agree with Mr. Bartlett that the landing is limited by out-to-out movement to the degree that he suggests ; I have seen aircraft landing on when there has been an out-to-out movement of 56ft, although modern aircraft and the aircraft of the future will make such a thing impossible.

The point I want to make is that I understand the ship has to be of the order of 1000ft long to give the optimum conditions for operation aircraft in relation to pitch. That means a very large ship ; and the matter is of considerable interest when we consider it in relation to the previous paper on the subject of docks.

Captain A. S. Bolt: I would like to recall the cause of an accident which occurred, because I think it points one of the morals to this question of the pitching of flight decks. There was nothing about the weather as such which would prevent flying, but for some unaccountable reason the motion of the ship appeared to be out of all proportion to the state of the sea. Therefore I cannot subscribe entirely to the author's statement that " It has been asserted, on good authority, that the regular seaway represents the most unfavourable conditions when compared with any arbitrary seaway, provided the maximum wave dimensions are comparative."

I agree that aircraft can be launched so long as heavy spray or water does not come over the forward end of the flight deck, but I do not agree that aircraft can necessarily be landed under conditions that admit of aircraft being launched ; in general the safe landing of aircraft ceases long before safe launching.

It is difficult to accept the figures given for maximum speed attainable at full power in waves of various lengths. Experience seems to indicate that higher speeds can be attained, although the possibility remains of heavy bumps forward and risk of structural damage to the ship. There may be many occasions on which high speeds are necessary under these conditions in order to launch or recover aircraft.

Mr. V. G. Shepheard : The problem of the efficient design of these ships in relation to future naval aircraft involves close examination of flight deck detail if maximum operational efficiency is to be achieved. Full aerodrome runway facilities for aircraft of increasing weight and speed have to be provided on a flight deck of very restricted length and width, and the restricted length has to be shared between flying off, landing on, safety barrier, and aircraft park requirements.

The motion of the flight deck involves important technical problems. Aircraft have to be strengthened against the touch-down velocities and accelerations involved, and if this strengthening is overdone there is a penalty in overall aircraft performance.

The pitching and heaving of the ship also provides problems in operating catapults and arresting gear. They affect even the approach technique of the aircraft themselves when landing on, so that more strain is thrown on the undercarriage and more severe conditions upon the arresting gear. With the great increase in speeds of flying off and landing on it is all the more necessary to have maximum assistance from air velocity down the

deck with the ship steaming into wind. This valuable air velocity is reduced if the ship's speed is set back in a seaway. There may be a temptation to regard this loss of ship speed as insignificant in comparison with modern aircraft speeds, but this is not so.

Mr. R. W. L. Gawn : The author notes the severe loss of speed in waves approximating in length to that of the ship dealt with. The maximum sea that would not entail a reduction of speed is also of interest and for the particular ship it appears to be represented by waves about 200ft long and 5ft high. Ship oscillations are also negligible in such waves, and taken in conjunction with the average probability curve, the result implies that for 50 per cent of the time spent in the oceans of the world, the ship will be free from oscillations and from any loss of speed due to seas. Peak motion and loss of speed may be expected for about 15 per cent of the time.

These conclusions are applicable to the particular size and form of the ship considered. It does not follow that this will be true for all ships of the size considered, since model experiments confirm that form and loading play an important part.

There is wisdom in the remarks concerning the appropriate freeboard for carriers and it would be of interest to have the views of merchant ship designers with liner experience. While the figures quoted are a good standard for ships of the size of carriers, there would be some point in arranging a larger coefficient for shorter ships, since testing seas are met more often by a ship of smaller length.

Professor Sir Thomas Havelock : In the paper it is assumed that the periods of pitch and heave are the same and that the respective motions are in the same phase ; is the evidence referred to that of actual observation and experiment, or are there theoretical considerations also?

In the flight deck plan there is a place marked " null point." For any motions of heaving and pitching there is at any moment an instantaneous centre of rotation ; but the position of this point will in general move backwards and forwards. There can be a stationary centre of rotation if the periods are the same, and if the phases of the motions are the same (or differ by 180 deg.). Consequently, if such a point is found to exist, these inferences are a necessary consequence.

Mr. Bartlett refers to the possibility of a modification of the damping putting the motions out of phase. According to the usual simple theory the exciting forces causing heave and pitch differ in phase by 90 deg. ; the damping is probably of the same order in the two cases, but it does not seem likely that damping could abolish a difference of phase of 90 deg. One must look to a more complete theory of the exciting forces for an explanation, taking account, for instance, of the actual position and attitude of the ship in relation to the waves and, if possible, the effect of the motion of the ship through the waves. Such a theory might possibly bring the exciting forces for heave and pitch approximately into phase under special conditions.

Professor A. J. Sims : Fig. 3 in the paper is the ordinary curve for dynamic response, and it is a very vital curve in our understanding of pitching and heaving ; I think it is because we cannot easily apply that curve to pitch and heave as we can apply it to rolling that we are still far from a clear understanding of these phenomena. At present we are forced, through lack of knowledge, to relate amplitude of pitch to the maximum wave slope and to relate the amplitude of heave to the maximum wave height. They are not true physical comparisons, however, and our knowledge of the subject is somewhat fogged until we can choose the correct physical parameter.

I have analysed some tank experiments in trying to relate certain assumptions for the damping coefficient for an aircraft carrier to an increase in the longitudinal inertia due to entrained water. These two complicated factors in pitch and heave are closely related and are difficult to separate. But I did get fairly close representation of the tank results by taking a value of K slightly less than 0·5 for pitching and an increase of inertia due to entrained water rather less than we usually assume ; it is my opinion that we tend to emphasise the effect of entrained water to a greater degree by neglecting the effect of the heave damping.

(*To be continued*)

The Physical Society's Exhibition

No. I

THE thirty-seventh annual exhibition of the Physical Society will be held at Imperial College, Imperial Institute Road, London, S.W.7, from Monday, April 13th, to Friday, April 17th. The exhibition is to be opened by Professor R. Whiddington, president of the Physical Society, at 10.30 a.m. on Monday and on that day will be open only to Fellows of the Society and the Press. From Tuesday to Thursday the exhibition will be open from 10 a.m. to 8 p.m., and on Friday, 17th, from 10 a.m. to 5 p.m., admission being by ticket only, on each day.

One of the events associated with this annual exhibition of instruments and apparatus is a display of entries for the craftsmanship and draughtsmanship competition organised by the Society. A very high standard of design and execution can be expected, almost as a matter of course, from the entries for this competition, which will be on show in the College. The prize giving of the competition will be held in the College at 5 p.m. on Monday, April 13th.

Three discourses will be delivered during the period of the exhibition. On Tuesday, at 6.45 p.m., Dr. E. C. Bullard (National Physical Laboratory) will give a discourse on " Seismic Study of the Ocean Basins." He will show how the technique developed, before the war, for making marine seismic observations in shallow seas, has been extended, since the war, to deep oceans and has yielded results of great interest to geologists. Using a few hundred pounds of explosive and a receiving device at a depth of a few hundred feet below the surface, results have been obtained at distances up to 80 miles. These results have shown the structure of the greater part of the ocean beds; whereas the discontinuity representing the base of the earth's crust is at a depth of about 35km under the continents, it is only about 5km below the ocean bed.

On Wednesday, April 15th, at 6.45 p.m., Dr. L. A. Jordan (the Paint Research Station) will give a discourse on "Particles, Pellicles, Pigments, Paint and Physics," illustrating the importance of physical considerations in research work applied to paint technology. Finally, on Thursday, April 16th, at 6.45 p.m., Professor W. V. Mayneord (Department of Physics, the Royal Cancer Hospital) will discuss "Scintillation Counting and its Medical Applications." He will describe some applications of scintillation counting to the detection and measurement of radioactive isotopes in the human body and will deal with recent attempts to form visual and photographic images of the spatial distribution of radioactive materials.

Exhibition

This year there will be 134 exhibitors, compared with 142 last year, but from advance information which we have received it is clear that there will be no diminution in the variety or technical interest of the instruments and apparatus on show. On the contrary, in many respects the scope of the exhibits has increased considerably.

There will be, for instance, nine stands showing strain gauge equipment, four showing instruments for surface measurement, and six showing ultrasonic equipment. Computers and associated equipment will be demonstrated by four exhibitors, and Geiger Muller counters or scintillation counters by nine exhibitors. Six stands will exhibit microwave components and demonstrations of microwave techniques, four stands will have displays of germanium crystals and units, and six exhibits will be concerned with semi-conductors and their application. Servomotors and servomechanisms will form the subject of four exhibits and there will be several stands showing vibration pick-ups and equipment for noise measurement.

A brief description of some of the exhibits is given in the following pages.

Cinema-Television, Ltd.

The " Cintel " Flying-Spot Microscope is being exhibited by Cinema-Television, Ltd., Worsley Bridge Road, Lower Sydenham, London, S.E.26. This apparatus is the commercial version of the original flying-spot microscope which was developed by Professor J. Z. Young, of University College, London, and formed the subject of an article in last week's issue of The Engineer (page 485). The microscope is designed to present a picture of high definition and large magnification with a low " noise " level.

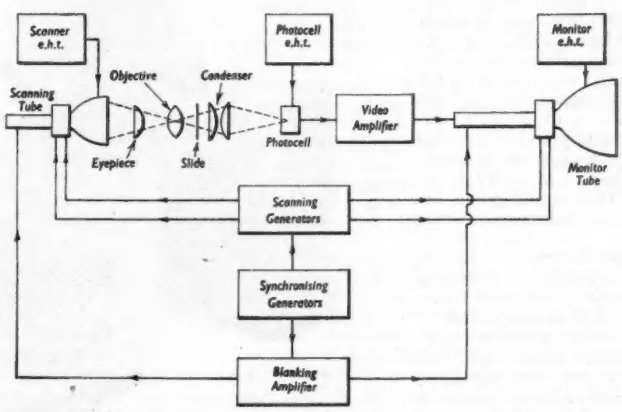

Fig. 1—Block Diagram of Flying-Spot Microscope—Cinema-Television

In the accompanying block diagram (Fig. 1) we show the main components of the instrument which is a combination of a microscope and a flying-spot scanner. The latter consists of an optically ground, flat-face scanning tube with a blue-violet phosphor on which is reproduced an unmodulated 360 line interlaced raster. This raster, by means of suitable optical reduction, the magnitude of which can be varied, scans a very small area of the specimen under examination. The transmitted light, modulated according to the density and configurations of the

specimen, falls upon a sensitive multiplier photo-electric cell, the output of which is amplified and used to modulate a raster on a 12in monitor tube. The raster of this monitor is synchronised with that of the scanning tube and any number of monitors may be operated from the one equipment.

The modulated raster on the monitor tube is a reproduction of the transmission pattern of the specimen, the magnification being determined by the area swept on the display screen and by the optical magnification of the microscope.

As can be seen from Fig. 2, the complete instrument is arranged in the form of a console, the monitor cathode ray tube, on the right of the microscope itself, being tilted at a suitable angle for viewing.

The scanning tube, which is aluminised, has an 87mm diameter ground optically flat screen, with a blue-violet phosphor coating. It is operated with a final anode potential of 25kV and has an afterglow time of less than 1 micro-second.

A Baker "4 AQ" compound microscope is recommended for the optical system, which is not supplied as part of the equipment. The microscope (Fig. 3) is fitted with a circular centring rotating mechanical stage, the stage edge being bevelled and calibrated to 360 deg. Both horizontal and vertical traverse are provided, there being 30mm movement in the vertical direction and 60mm in the horizontal.

To exploit the full potentialities of the equipment the objective lens should be "apochromatic" so that it can be used in the near ultra-violet light region: it is fully corrected for red, blue and green light. For maximum light transmission the lens should be bloomed. The turret mounting will hold three lenses and is fitted with Beck objectives having focal lengths of 2mm, 4mm and 8mm respectively.

The choice of condenser follows normal microscopical practice and two kinds are used—the Baker "Achromatic," with the 4mm and 8mm objectives, and the Watson "Holoscopic Immersed," with the 2mm objective. Two eye-pieces, a ×11 and a ×25, are used. A suitable range would be ×5 to ×25.

The photocell is a transparent-cathode, eleven-stage multiplier giving a total magnification of $\times 10^7$. It is at present operated at 160V per stage.

The video amplifier is fed from the photo-cell via a cathode follower, the output impedance of which is 100Ω. The amplifier is fully compensated and has a frequency response extending from 20 c/s to 3 Mc/s, d.c. restoration being utilised to re-establish the black-level. A number of 100Ω output points are provided from which a video signal of 5V peak-to-peak can be obtained for operating external monitors and counting equipment.

With the Baker microscope stand the total optical magnification, with a 2mm objective, a ×25 eyepiece and a distance of 160mm from eyepiece to objective, is 2000. The raster ratio magnification is 4 and the total magnification is, therefore, 8000, with the equipment described. Although the final resolution of the instrument has yet to be determined, the manufacturer states that the system has, so far, resolved 100,000 lines to the inch. The resolution may, therefore, be expressed as 0·254μ.

The console, as illustrated, measures approximately 5ft long by 3ft wide by 2ft 6in high to the desk top. Besides the optical controls mentioned above, the console houses electrical controls for scan brightness and focus, monitor brightness and contrast, monitor focus and

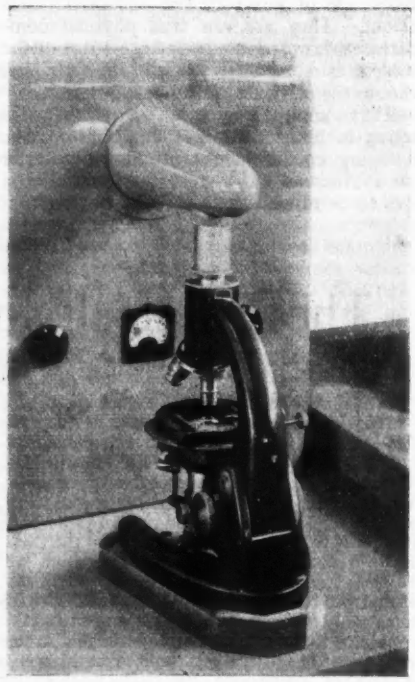

Fig. 3—Details of Microscope—Cinema-Television

photo-cell "on/off." The approximate power consumption is about 500W on a single-phase, 50 c/s, 200–250V supply.

The flying-spot microscope offers a number of advantages compared with conventional techniques.

First, the size and intensity of the display facilitate demonstrations to large audiences. Secondly, the effective contrast of the specimen may be varied simply by a potentiometer control. This facility reduces the need for staining low contrast specimens and improves the contrast of specimens that normally cannot be stained.

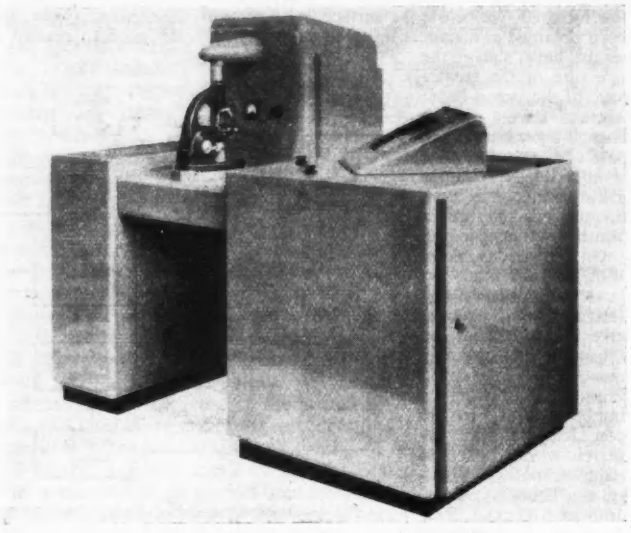

Fig. 2—Flying-Spot Microscope—Cinema-Television

Thirdly, in conventional microscopy a high light intensity can cause damage or distortion to a specimen, especially if live. This risk is obviated with the flying-spot microscope, for, although the peak intensity of the flying-spot is high, the average light intensity is low.

By the use of ultra-violet radiation from the scanning tube and an ultra-violet sensitive photo-cell, the resolution of the system is as great as that obtained with conventional photographic methods.

Fourthly, the apparatus permits the rapid, accurate and automatic counting and sorting of particles and thus completely replaces the normal slow, laborious and inaccurate manual methods.

Ferranti, Ltd.

Among the new exhibits to be shown by Ferranti, Ltd., Hollinwood, Lancs, is a high-speed oscillograph for recording transient voltages, such as would occur on power transmission lines and associated electrical equipment. The traces can be observed visually and photographed simultaneously, the size of the negative being 3½in by 2½in. As illustrated in Fig. 4, the oscillograph consists basically of two Ferranti electrostatically deflected tubes. They operate at 15kV d.c. and have a common tripping circuit and two independent time bases, the fastest sweep being two microseconds. The demonstration model displays the magnitude and wave shape of the voltage produced by a model impulse generator, which gives approximately 80kV at no load.

As illustrated, the complete oscillograph and control gear are self-contained in a robust sheet steel cubicle with interlocked doors conveniently placed for inspection and adjustment. The oscillograph tubes are specially designed sealed-off hot cathode glass tubes operating up to 15kV. Two tubes are incorporated, each with a separate set of time bases, but with a common tripping circuit so that it is possible to obtain two independent records of the conditions in a circuit from a single applied impulse. The photo-

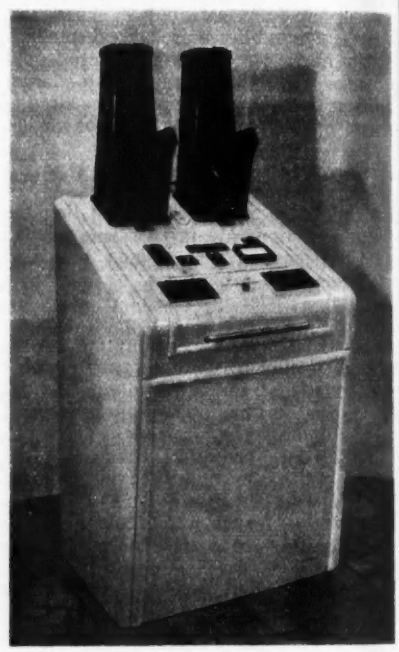

Fig. 4—High-Speed Oscillograph—Ferranti

graphic arrangements incorporate two cameras, one for each tube, so that both tubes can be used simultaneously for recording. The size overall is approximately 4ft 6in high by 2ft 9in deep by 3ft wide.

For the high-voltage supply to the cathodes of the cathode ray tubes there is a separate d.c. unit having a nominal output of 15kV d.c. with one end earthed and consisting of step-up transformer, rectifiers and smoothing condenser.

There is only one tripping circuit. Tripping impulses of the order of 100V are required and the delay of the whole oscillograph is of the order of 1/20 to 1/10 microsecond. Two sweep circuits are used. They are independent of one another and supply two independent cathode ray tubes. Each base is tripped simultaneously from the common tripping circuit. The first has sweep speeds of 1·5, 6, 50, 200 and 400 microseconds; the second has sweep speeds of 6, 50, 200 and 400 microseconds. None of the traces are linear, but the longer ones are almost completely exponential.

Two specially designed Ferranti cathode ray tubes are used. They are made of glass, one sealed-

off permanently and one magnetically focused. The cathode voltage is 15 kV d.c., and a stabilised supply is used for the focusing coils. The colour of the trace on the screen is blue.

For calibration a separate oscillator is provided for each time base and is controlled by a switch. The following frequencies are obtainable by switching: (*a*) 5 Mc/s, 1 Mc/s, 250 kc/s and 100 kc/s; (*b*) as for (*a*), but omitting the 5 Mc/s frequency.

For voltage calibration bias lines can be drawn in the direction parallel to the sweep which is horizontal and if the supply voltage to the oscillograph is maintained constant then the lines will be kept equidistant to within 2 per cent. It is possible to connect an external voltmeter across the bias supplies as a check on the constancy of supply, but a built-in instrument is not provided. High stability resistances are used on the bias supply and the load is arranged to be steady for all practical purposes.

Apart from the switches already mentioned, the following controls are supplied on the operating panel: double-pole main switch; manual sweep trip; focusing coil current, two pre-set controls; "cut-off" bias on each tube, two controls; pulse voltage per tube, two controls; thyratron bias voltage, two preset controls.

With the exception of the two tripping thyratrons (one for each polarity of tripping), all the valves (twelve rectifiers and ten pentodes) used are high-vacuum tubes.

The normal design is arranged for 3¼in by 2¼in. photographic plates or 3¼in. by 2¼in. roll film. The lenses used are f. 1·9, of 4in focal length, the object and image sizes being approximately equal and filling the above negatives. No adjustment is provided for altering the ratio of object to image size.

On the same stand there will also be a demonstration of xerography—a method of reproducing a photographic image without requiring wet chemical processing for development and fixation of the image. This process involves a simple application of electrostatics and a photoconduction effect which is characteristic of a number of electrically insulating solids (such as amorphous selenium) during irradiation. A positive or negative picture can be produced by this method in about a minute.

The company is also demonstrating a demountable cathode ray tube unit designed for carrying out experiments on the properties of fluorescent powders and on the design of electron guns. It is a self-contained unit, which is readily evacuated by a silicone diffusion pump backed by a rotary oil pump. Accelerating voltages, up to 30kV, are obtained from an r.f. unit and provision is made for focus, line and frame scan.

Siemens Research Laboratories

Electric arc discharges in rare gases and vapours frequently exhibit phenomena of general scientific interest, and some of these effects either in commercial equipment or in specially built discharge tubes will be demonstrated by Siemens Research Laboratories, Preston.

One demonstration will show how readily horizontally operated arcs can be disturbed by convection effects. Another demonstration will show the dependance of luminance distribution on the electrical polarity of the electrodes. By viewing the a.c. arc through a synchronised shutter it will be possible to observe the pronounced difference in luminance with alternating and direct currents when the arc length is short.

Another phenomenon is that, in an arc established through a rare gas, a quantity of metallic vapour (such as mercury or sodium) can only be excited to emit its characteristic radiation if the temperature of the walls of the containing vessel is sufficiently high. It will be shown that, by varying the temperature of a definite length of the tube wall, the colour of the light emitted throughout this length can be changed to the one that is characteristic of the metal vapour.

Another property of gaseous discharges is that the spectral quality and luminous efficiency of the radiation from an arc discharge can be influenced by the current density and the power loading. To show this effect a comparison will be made between a continuously operated arc in xenon and the familiar flash discharge imposed on the same tube.

W. G. Pye and Co., Ltd.

Among the instruments to be shown by W. G. Pye and Co., Ltd., Cambridge, is a sensitive d.c. microvoltmeter which is a commercially produced version of the galvanometer amplifier that was shown last year.

In the new instrument a d.c. galvanometer coil has a second coil, lying on the same axis, rigidly attached to it. The second coil moves in an alternating field produced in the gap of a laminated iron-cored system. When this coil lies in the plane of the alternating field no alternating voltage is induced in it, but when the coil moves to either side a voltage is induced which changes phase as the coil passes through the plane of alignment. When a d.c. voltage is applied to the galvanometer coil this coil rotates and an a.c. voltage is produced in the second coil. The a.c. voltage is amplified and converted back to d.c. by means of a phase-sensitive detector. The amplified direct current is passed through a microammeter and also through a small resistance to provide negative feedback.

Thus the sensitivity of a freely suspended reflecting galvanometer is obtained in an instrument no larger than the usual self-contained galvanometer, making it particularly suited for use with precision potentiometer and resistance bridges and similar applications. The instrument is provided with a centre-zero scale. The maximum sensitivity is $\pm$ 10μV; a switch gives multiplying factors of 1, 10, 100 and 1000. The input impedance is 50 ohms, and the period on the most sensitive range is 0·5 second; on the other ranges the period is shorter.

Another exhibit on this stand will be the Pye

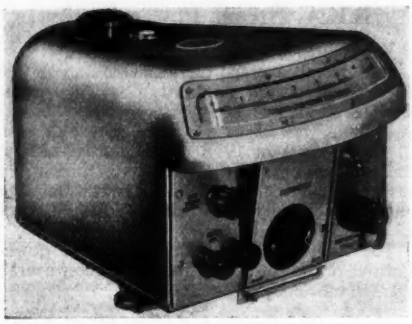

Fig. 5—Reflecting Fluxmeter—Pye

"Psychogalvanometer," which has been specially designed for psychological research on temperament, to be carried out by the Royal Eastern Counties Institution, Colchester. It measures the change in skin conductivity produced by change of mental activity, particularly that due to emotional behaviour. Neuro-anatomically, the psychogalvanic response (P.G.R.), or galvanic skin reaction (G.S.R.), as it is sometimes called, is mediated by the sympathetic nervous system.

The apparatus is essentially a Wheatstone bridge. Two electrodes are placed at appropriate points on the subject and the skin resistance between these electrodes forms one arm of the bridge. To follow the changes in skin resistance directly without continual rebalancing of the bridge the following procedure is adopted. A variable resistance is placed in series with the subject and, before starting an experiment, the electrodes are short-circuited together and the bridge is balanced by adjustment of this resistance. The subject resistance is then inserted and the bridge is rebalanced by reducing the variable resistance. The total resistance in the subject arm must then be the same as that before connection of the subject. Under these conditions, if a fixed voltage is applied to the bridge, the out-of-balance deflections of the galvanometer due to changes of subject resistance will bear a fixed relation to these changes. The procedure is therefore to read the out-of-balance galvanometer deflections produced by changes in the emotional condition of the subject, thus providing a continuous indication of the subject resistance. The interpretation of these deflections in terms of resistance change is very easily made by changing the variable resistance by a known amount and observing the change in galvanometer deflection.

A built-in voltmeter and a dry battery are provided so that the apparatus is entirely self-contained apart from the galvanometer. The bridge has been designed for use with the Pye "Scalamp" galvanometer.

The same company is also exhibiting a reflecting fluxmeter (Fig. 5) mounted in the "Scalamp" case with an anti-parallax scale which can be read easily from any position. The residual restoring torque is very low, so that the deflection drifts back to zero very slowly. High-resistance search coils (up to several hundred ohms) may be used without appreciable error—a great advantage when very small search coils are required. A torsion head is provided for initial zero setting. To enable the spot to be returned to zero quickly and accurately when required, a special electrical return device operated by a single knob is incorporated. When the knob is pressed in and turned to right or left, the spot travels rapidly to right or left and can thus be brought quickly to an approximate zero position. When the knob is released and similarly turned, the spot travels slowly and can be accurately adjusted on the zero mark. The full-scale reading is 700,000 lines and readings can be easily estimated to 1000 lines. As the movement is freely suspended levelling feet and spirit level are provided, but a rigid foundation is not required and the instrument may be used on an ordinary bench. The whole equipment is built-in; the lamp and electrical return device operate from 200–250V a.c. or from a 4V battery. The fluxmeter can also be used as a sensitive galvanometer (period 15–20 seconds and current sensitivity 1000 mm/μA).

Royal Aircraft Establishment

Useful information on aircraft cabin heating can be obtained with the help of the "Pyroheliometer," which will be demonstrated by the Royal Aircraft Establishment, Farnborough. This instrument is designed to measure the solar radiation falling on an aircraft in flight and thereby to give information allowing the heat balance in aircraft to be calculated under various conditions.

The instrument is based on the principle used by Callendar in his radiation balance and it consists of two copper cups blackened on the inside: one cup acts as a black body receiver for the radiation and the other acts as a compensator. A constantan wire connects the two cups and carries a measured and controlled current in such a direction that the Peltier effect cools the receiver cup and heats the other. A thermopile, having one set of junctions on each cup, is connected to a galvanometer to indicate any temperature difference between the two cups. In operation the current through the Peltier couples is adjusted to make this temperature difference zero.

Then since there is no heat flow between the cups and since the radiation losses from the two cups has been balanced, the radiation in watts incident on the receiver cup is equal to

$$I\theta \,.\, dE/d\theta,$$

where I is the current through the Peltier couples, in amperes, $dE/d\theta$ is the Peltier coefficient of the couple in volts per deg. Cent., and θ is the absolute temperature of the cups in degrees K.

In the instrument exhibited the current is measured by a milliammeter, and the absolute temperature by a resistance thermometer. The value of $dE/d\theta$, which is determined by the metals forming the Peltier junction and by θ, can be obtained from tables.

The instrument is particularly suitable for measurements in aircraft because the convection losses for the two cups are balanced, which means that the radiation measurement is independent of atmospheric density and of the altitude of the instrument to the vertical.

The Royal Aircraft Establishment will also exhibit a strain gauge balance with a self-balancing Wheatstone bridge for wind tunnel work. The strain gauge rig is designed to measure four components of the aerodynamic forces on a wind tunnel model, namely, normal force, pitching moment, side force and yawing moment. In association with each component there is a Wheatstone bridge consisting of four strain gauges cemented to the model support. Each

component is determined by measuring the change of the ratio arms required to balance the bridge.

Servo-operated potentiometers have been developed for this equipment to facilitate rapid and accurate balancing of the bridge. The bridges are fed with alternating current and the out-of-balance voltage is applied to an amplifier which has a gain of 3×10^8 and can function with inputs down to 0·3 microvolts. Sensitivity can be varied over a 60 : 1 ratio in twelve steps, and throughout the range the instrument error is within 0·2 per cent of the maximum reading. Bridge balance is achieved from full-scale deflection in four seconds after the establishment of stable conditions.

One of the difficulties in using these bridges for wind tunnel work springs from the fact that the air flow, instead of being steady, may have a low-frequency oscillation. The magnitude of the force associated with this oscillation may be many times that of the steady force. The difficulty of measuring the steady force has been overcome by the use of a discriminator, which embodies rectifier bridges and can isolate the effect of a steady load, discarding the effect of the larger low-frequency load. The balancer units are fitted with transmitters, whereby continuous traces or punched card records can be made.

STANDARD TELEPHONES AND CABLES, LTD.

A newly designed test set for measuring telegraph distortion is one of the equipments that will be exhibited by Standard Telephones and Cables, Ltd., Connaught House; Aldwych, London, W.C.2.

This testing apparatus uses cold cathode gas-filled "relay" tubes controlled by an oscillator to generate the test signals recommended by the C.C.I.T. and thus replaces the electro-mechanical cam machine driven by an electric motor that hitherto formed the basis of such test sets. It embodies a self-starting transmitter and relay, and switching circuits are provided to allow the use of remote control. The new technique results in a substantial reduction in size and weight and effects considerable economy in

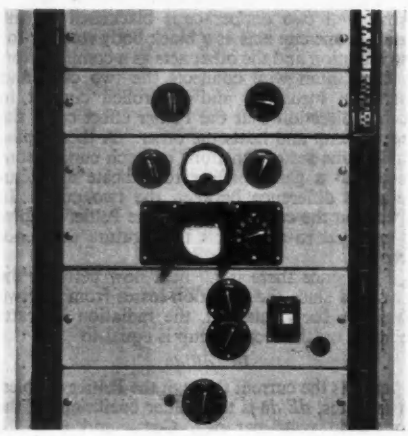

Fig. 6—Telegraph Distortion Test Set—Standard Telephones

maintenance in that there is no longer any need for the adjustment of relay springs associated with the cam machine. The transmitter normally operates at speeds between 50 and 60 bauds, but with an independent oscillator and drive circuit it may be operated at speeds up to 200 bauds. The test set will be demonstrated with a source of voice-frequency tone and with a relay to provide the requisite distortion.

The test set consists of a three-unit panel embodying an oscillator, frequency dividers and time base, and a four-unit panel embodying a cathode ray tube with its e.h.t. supply circuit, a pulse amplifier and a multi-vibrator.

The equipment (Fig. 6) provides a number of test facilities. As a receiver it enables accurate measurements to be made of the synchronous distortion of a continuous train of double current telegraph signals at 50 or 60 bauds. It also allows the wave form of a continuously repeated d.c. telegraph signal to be examined and thus enables relay contact bounce to be investigated. Thirdly, it facilitates determination of the frequency-accuracy of v.f. oscillators producing the standard C.C.I.T. frequencies of 420, 540 and 660 c/s. Fourthly, it transmits accurate square wave reversals at 2 : 2, 50 bauds, or 2 : 2, 60 bauds, and these signals can be used for lining up and testing v.f. telegraph signals.

Another instrument to be shown on this stand is the "Humicon" humidity detector, which consists of two perforated metal plates about 7in in diameter, mounted 1in apart, the space between the plates being filled with ravelled glass silk. This assembly behaves as a variable impedance when it is connected to the 230V a.c. mains supply through a resistance of 2 megohms. Changes in impedance of the "Humicon" caused by variations in relative humidity produce a varying voltage across it. This voltage can be applied to a series of thyratrons, which can in turn be made to operate outside circuits.

In the case of the vehicle of the "Standard" precision approach radar equipment (G.C.A.) the "Humicon" is made to control electric motors which operate flaps on the vehicle either to close the system or allow ingress and circulation of external air. If the humidity is excessive, heaters are switched on to reduce the relative humidity. Automatic humidity control is thus obtained.

The exhibit will take the form of a working model showing a "Humicon" unit controlling the humidity in a "Perspex" chamber.

(To be continued)

B.E.A. Steam Power Station Efficiencies

THE overall average thermal efficiency of the British Electricity Authority's steam power stations (totalling nearly 300) for the calendar year 1952 was 22·61 per cent compared with 21·79 per cent in 1951. The improvement in thermal efficiency, 0·82 per cent, represents a saving of over 1,300,000 tons in coal consumption and an economy in working costs of over £3,000,000.

The following are the twenty steam power stations of the Authority with the highest overall thermal efficiency for 1952 :—

Station	Thermal efficiency per cent
Littlebrook "B," Dartford, Kent	29·95
Dunston "B" II, Newcastle upon Tyne	29·65
Portobello H.P., Edinburgh	29·46
Skelton Grange, Leeds	29·19
Bromborough, Cheshire	28·88
Stourport "B," Worcs.	28·84
Battersea "B," London	28·71
Poole, Dorset	28·31
Braehead, Renfrew	27·79
Agecroft H.P., Salford	27·20
Blackwall Point, London	26·66
Clyde's Mill H.P., Glasgow	26·66
Fulham, London	26·63
Cliff Quay, Ipswich	26·63
Stuart Street H.P., Manchester	26·47
Brimsdown "B," H.P., near Enfield	26·41
Hams Hall "B," near Birmingham	26·24
Llynfi, nr. Bridgend, South Wales	26·23
Staythorpe, Newark	26·18
Croydon "B," Surrey	26·02

Three stations, namely, Brunswick Wharf, North Tees "C" and Huncoat, which did not operate throughout the whole year, achieved thermal efficiencies for their periods of commercial operation of 28·41, 26·93 and 26·60, respectively.

The figures show the need for building new power stations and installing new plant in older stations to replace time-expired plant of low efficiency. Well over one-tenth of the Authority's present total output capacity is provided by plant over twenty-five years old.

The British Electricity Authority states that its present plant programmes should make it possible to reach an overall average thermal efficiency of 26 per cent in 1960.

"EFEM" DIEHEADS.—We are informed by Charles Winn and Co., Ltd., Granville Street, Birmingham, that it is now the sole concessionaire in this country for the "Efem" precision diehead. At present two types of dieheads are available for delivery from the firm's stock in Birmingham, the "Style H," using "Coventry" chasers, and the "Style G," using "Geometric" chasers. Chasers for use with the dieheads are made by the company, but existing chasers of "Coventry" and "Geometric" types can also be used.

B.S.R.A Resistance Experiments on the "Lucy Ashton"*

By J. F. C. CONN, D.Sc.,† H. LACKENBY, M.Sc.,‡ and W. P. WALKER§

No. III—(*Concluded from page 490, April 3rd*)

In this paper the results of the resistance trials in the "Lucy Ashton" are analysed to establish ship model correlation for the rated hull conditions. Test conditions and the work carried out to establish the roughness effect of several surface conditions are described, together with the wind tunnel tests. The resistance of the "Lucy Ashton" models are extrapolated on the basis of the Schoenherr, Telfer and Prandtl-Schlichting lines and the Froude method, and the predictions compared with the actual results.

The Ship Model Correlation.—The correlation of the ship and model results has been effected by comparing the full-scale resistance with predictions made from the model results according to various skin friction formulations. The following methods of making the skin friction correction between model and ship have been considered : the R. E. Froude "0" values, the Schoenherr skin friction line, the Prandtl-Schlichting skin friction line, and the Telfer extrapolator.

The best overall picture of the ship model correlation on the Schoenherr formulation is given in the extrapolation diagram, Fig. 5, which shows the results for all the models in addition to the full-scale ship resistance.

The vertical scale is the total resistance coefficient $C=R/\frac{1}{2}\rho V^2S$ (S being the wetted surface of the model or ship hull), and the horizontal scale is Reynolds number $R_n=VL/\nu$ (L being the length of model or ship). Whereas the

NOMENCLATURE AND SYMBOLS

A = Cross-sectional area of water in experiment tank.
A_m = Midship section area.
A_T = Transverse projected area of the ship above the waterline.
A_w = Area of waterplane.
a = Mean cross-sectional area of model $=\frac{\nabla}{L}$.
B = Maximum breadth to mean thickness of shell.
b = Breadth of water surface in experiment tank.
C = Resistance coefficient $=\frac{R}{\frac{1}{2}\rho V^2S}$.
C_f = Frictional resistance coefficient $=\frac{R_f}{\frac{1}{2}\rho V^2S}$.
C_b = Block coefficient $=\frac{\nabla}{LBd}$.
C_m = Midship area coefficient $=\frac{A_m}{Bd}$.
C_p = Prismatic coefficient $=\frac{\nabla}{A_mL}$.
C_w = Waterplane area coefficient $=\frac{A_w}{LB}$.
d = Mean moulded draught to top of sagged keel.
e.h.p. = Effective horsepower.
g = Acceleration due to gravity.
k = Wind resistance coefficient $=\frac{R}{\frac{1}{2}\rho V_r^2A_T}$.
k_s = Equivalent sand grain size.
L = Length of ship (*LBP*).
R = Resistance in general.
R_f = Frictional resistance.
R_r = Residuary resistance.
R_t = Total resistance.
R_n = Reynolds number $=\frac{VL}{\nu}$.
S = Wetted surface area.
$t°$ = Temperature of water.
V = Speed.
V_r = Relative wind speed.
v = Tank carriage speed.
Δ = Displacement.
∇ = Volume of displacement.
δh = Depression of water level in way of model due to backflow.
δv = Backflow velocity in way of model due to constriction.
ν = Coefficient of kinematic viscosity.
ρ = Specific density.
ϕ = Ratio of frictional resistance to total resistance $=\frac{R_f}{R}$.
© = R. E. Froude's resistance constant
$=\frac{125S}{\pi\nabla^{\frac{2}{3}}}C=\frac{2938R}{\Delta^{\frac{2}{3}}V^3}=427\cdot1\frac{\text{e.h.p.}}{\Delta^{\frac{2}{3}}V^3}$,
where R and Δ are in tons (salt water) and V is in knots.
AP = After perpendicular.
FP = Forward perpendicular.
ABP = Amidships between perpendiculars.

*Institution of Naval Architects' Spring Meetings. Abstract.

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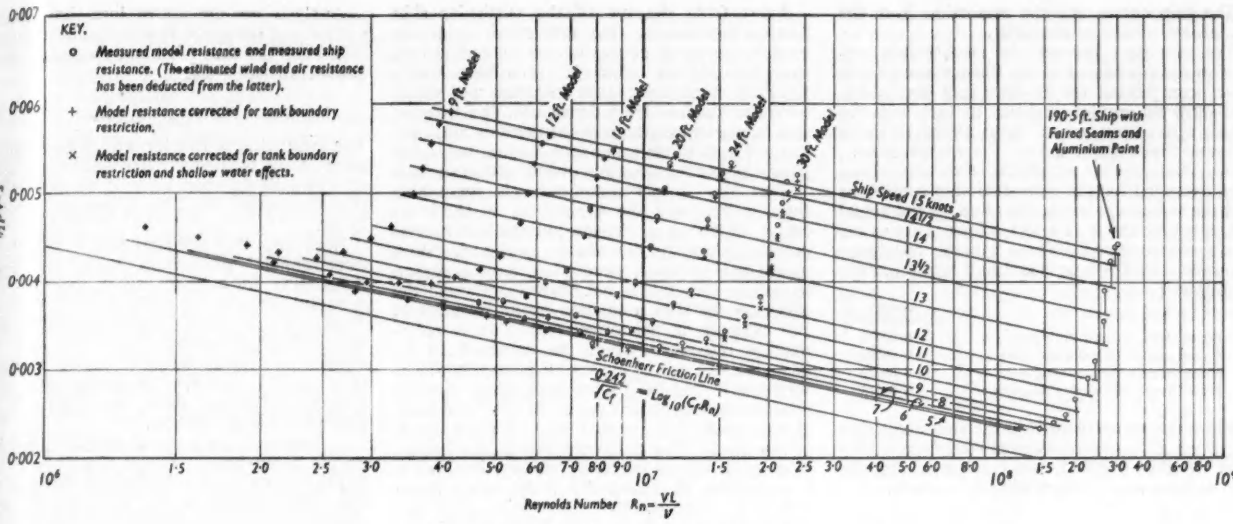

KEY.
o Measured model resistance and measured ship resistance. (The estimated wind and air resistance has been deducted from the latter).
+ Model resistance corrected for tank boundary restriction.
× Model resistance corrected for tank boundary restriction and shallow water effects.
9ft. Model
12ft. Model
16ft. Model
20ft. Model
24ft. Model
30ft. Model
190·5 ft. Ship with Faired Seams and Aluminium Paint
Ship Speed 15 knots
Schoenherr Friction Line
0·242/√Cf = Log10(CfRn)
Scale of R/½ρV²S
Reynolds Number Rn = VL/ν

Fig. 5—Extrapolation Diagram on Schoenherr Basis

vertical scale is an ordinary linear scale, the horizontal scale has been contracted as explained below in such a manner that Schoenherr's friction coefficients lie on a straight line over the range of Reynolds numbers. This artifice facilitates the extrapolation of the model results to the full scale.

The Schoenherr friction line is given by the following relation :—

$$\frac{0{\cdot}242}{\sqrt{C}} = \log_{10}(CR_n)$$

This formula is rather cumbersome for plotting, but over the range of Reynolds numbers covered by the ship and models (that is, 10^8 to 10^9), the formula can be accurately represented by the expression

$$C = k\,(\log R_n)^m,$$

where k and m are constants having the values 0·4631 and $-2{\cdot}6$ respectively. By making the horizontal scale $(\log R_n)^{-2{\cdot}6}$ the Schoenherr coefficients appear as a straight line over this range.

For all models, the total measured resistance has been plotted at a series of corresponding speeds in knots for the full-size ship varying from 5 to 15 knots.

The observations indicated by circle spots represent the measured model resistance with trip wire ; those without trip wires have not been used in this ship model correlation.

The intercept between the total model resistance and the Schoenherr line therefore represents the residuary resistance in each case on the usual assumptions that (i) the skin frictional resistance of the models is equal to that of planes having the same length and wetted surface ; (ii) skin frictional and wave making resistances are independent and separable.

Further, according to Froude's Law of Comparison, the residuary resistance coefficient, as represented by these intercepts, should be constant for the different models at corresponding speeds, or at constant Froude number. Accepting these assumptions, cross curves of constant corresponding speed for the ship should be a series of straight lines all parallel to the basic Schoenherr line. The ship prediction is given by extrapolating these cross curves of constant Froude number until they intersect the verticals corresponding to the appropriate Reynolds numbers for the ship.

The cross curves of corresponding ship speed do align themselves very nearly parallel to the Schoenherr line up to the 20ft model. For the 24ft and 30ft models, there is a tendency for the circle spots to rise above their lines, particularly at the higher speeds, so that the extrapolation of the model results would come above the corresponding measured ship resistance. This would be inadmissible in that the ship was still relatively rougher than the models, and therefore the model extrapolation should come below the ship figures.

It was suspected that the larger models were affected by the restricted breadth and depth of the N.P.L. No. 1 experiment tank. The model results were therefore corrected for this effect and the results are shown by the Maltese crosses below the circles. This correction had a noticeable effect on the 24ft and 30ft models, the maximum correction on the latter being 3½ per cent. The spots for the 30ft model still tended to rise above the level of the cross curves and it was considered that this might be accounted for by shallow water effects on the wave-making resistance, as the 11ft 6in depth of water in No. 1 tank, N.P.L., was relatively shallow for a model of 30ft length.

The Director of Naval Construction, Admiralty, investigated the effect of shallow water on a 30ft wax model of the "Lucy Ashton" in the Haslar tank, which has an adjustable false bottom. Tests were carried out at two depths, namely, at 11ft 6in and at 18ft, and the resistance was higher at the shallower depth, the difference amounting to about 2½ per cent at the high speeds. These additional corrections are shown by the diagonal crosses and the observations now align themselves with those of the other models.

By extrapolation of the cross curves to the appropriate ship Reynolds numbers the smooth ship prediction is obtained, and is compared with the measured ship results for the smoothest hull surface condition. It will be noted that the smooth ship prediction from the models comes below the measured full-scale resistance and this effect is discussed below.

Before leaving Fig. 5 it is of interest to draw attention to a feature of this method of presentation, due originally to Telfer, which involves simultaneous compliance with the Reynolds and Froude laws. This is, that in aligning the ship and model results no temperature correction is necessary. This is automatically taken into account by calculating the resistance coefficients and Reynolds numbers using density and kinematic viscosity corresponding to the actual temperature of water during the tests. No temperature correction has therefore been made, but the ship results have been corrected for the items described in Section A in order to make them comparable with the model values. Further, a small deduction has been made for the estimated skin frictional resistance of the bar keel, which varied from about 3 per cent at the lowest speeds to about 1 per cent at the highest.

The essence of the ship model correlation on the Schoenherr basis is shown in Fig. 6, where the ship results and the smooth ship prediction from the models are compared. In this figure all results have been reduced to a standard emperature of 59 deg. Fah.

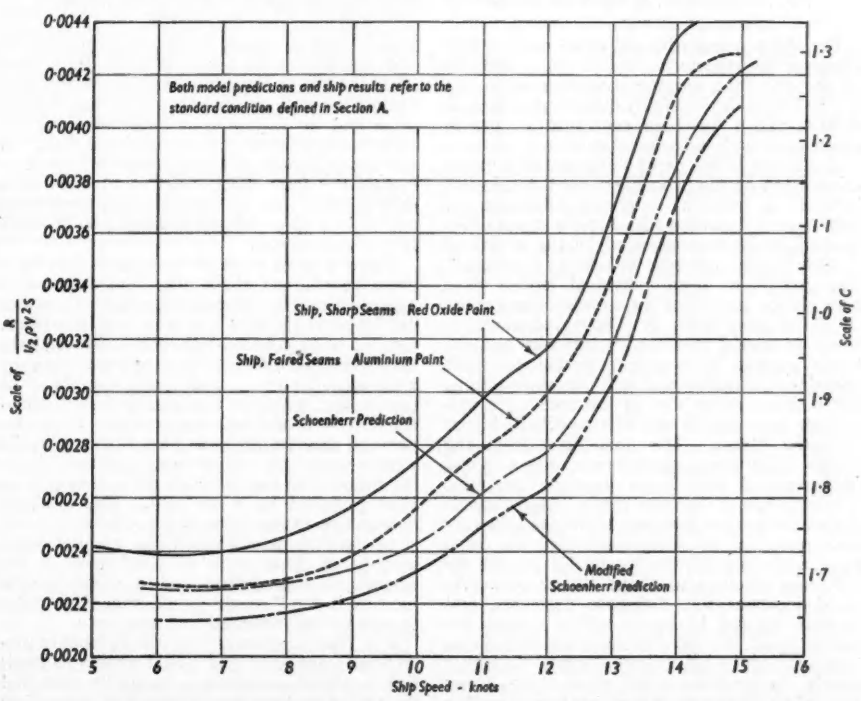

Both model predictions and ship results refer to the standard condition defined in Section A.
Ship, Sharp Seams Red Oxide Paint
Ship, Faired Seams Aluminium Paint
Schoenherr Prediction
Modified Schoenherr Prediction
Scale of R/½ρV²S
Scale of C
Ship Speed - knots

Fig. 6—Comparison of Full-Scale Resistance with Schoenherr Smooth Ship Predictions from Models

The ship curves and the prediction from the models are of similar character.

The intercepts between the smooth-ship prediction on this basis and the full-scale resistance have been plotted for all four ship conditions. and show no regular tendency to vary with the speed, apart from a rise up to about 13 knots followed by a reduction at the higher speeds. These intercepts or roughness allowances have been averaged for the individual ship conditions and the values are much the same, as the actual values round about 11 knots, which is about the ship's service speed. These average roughness allowances for the four naked hull conditions are as follows :—

	Average allowance on C_f
(i) Sharp seams with red oxide paint	+0·00030
(ii) Faired seams with red oxide paint	+0·00020
(iii) Sharp seams with aluminium paint	+0·00019
iv) Faired seams with aluminium paint... ...	+0·00013

From the above there is in the smoothest ship condition a significant average roughness allowance on C of 0·00013, which suggests that the hull surface was not hydraulically smooth.

Apart from the use of the particular skin friction formulation, the predictions from the models discussed above involve two important assumptions, viz. that in accordance with Froude's hypothesis, skin frictional and wave-making resistance are independent, and that the skin frictional resistance of the three dimensional form of both models and ship is equal to that of planes having the same length and wetted surface.

That the former assumption is reasonable from is apparent the parallelism of the cross curves of constant Froude number (or corresponding ship speeds) shown in Fig. 5. With regard to the second assumption, there is reason to believe that this is not correct, although the effect on the ship prediction is not very great. For example, at the lowest speeds where wave-making resistance would be expected to be negligible the model curves all align themselves very nearly parallel to the basic plane friction line, but they lie some 8 per cent higher and there is little doubt that the real model friction line is at that level. This difference may be due in part to some deficiency in the Schoenherr line, but it is more likely that most of it is due to the three-dimensional or form effect on skin friction. This augment of plane friction due to form effect is caused by the augmented velocity distribution around the form as compared with that of a flat plate and by variations in pressure along the form brought about by the frictional flow. In the circumstances it would appear incorrect to include this form effect, which is attributable to skin friction, into the wave-making component and scale it up to full size according to Froude's law of comparison.

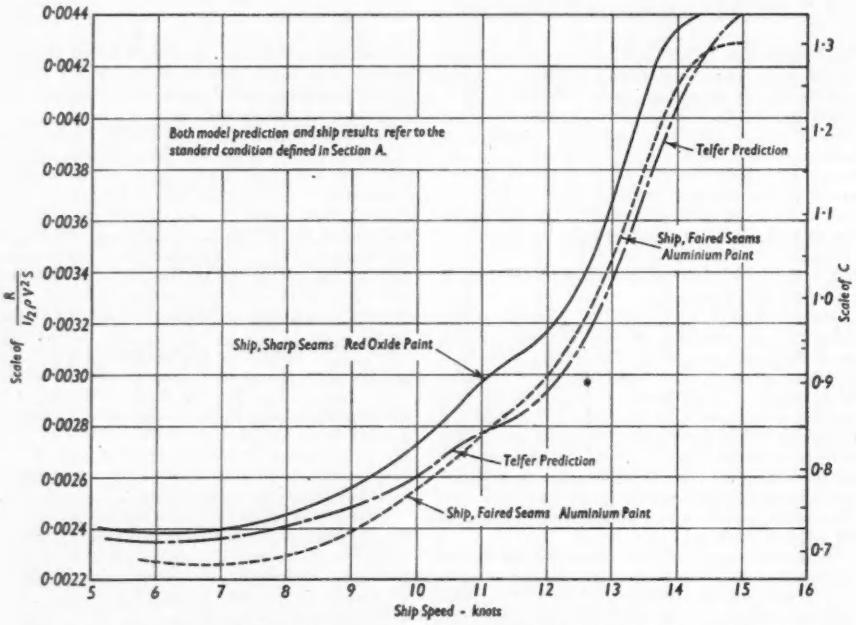


Fig. 7—Comparison of Full-Scale Resistance with Telfer Smooth-Ship Prediction from the Models

For sharp seams with red oxide paint, which corresponds to the normal clean service condition of the ship, the average roughness allowance is +0·00030. This is fairly close to the figure of 0·0004, which has been suggested for use in conjunction with the Schoenherr line.

A diagram in the paper shows the ship model comparison on the Schoenherr basis, but in this instance a uniform roughness allowance of 0·0004 on C_f has been added to the smooth ship predictions, as recommended by the American Towing Tank Conference for "clean new vessels." The predictions from individual models have been shown instead of the averaged prediction, which is plotted in Fig. 6. These predictions are based on model results with trip wire and the larger models have been corrected for tank boundary restriction and shallow water effects. The diagram shows that at low speeds the predictions from the 9ft and 12ft models lie higher than the others. The predictions from the models lie in a very narrow band with a spread of between 1 and 2 per cent at the most over the whole of the speed range. At low speeds the predictions are generally higher than the full-scale resistance for sharp seams and red oxide paint, and except for the 9ft and 12ft models the difference amounts to about 10 per cent. As speed increases this difference decreases, and between 11 and 13 knots, which includes the service speed, the predictions are within about 1 per cent of the full-scale resistance. At higher speeds the predictions fall some 2 to 3 per cent below the ship resistance, but come together again just above 14 knots.

There is some evidence to suggest that for a given geometrical shape the form augment is roughly a constant percentage of the corresponding flat plate friction of the same length and area. On this basis it would seem reasonable that the appropriate skin friction extrapolator should be a line some fixed percentage higher than the plane friction line, which is tangential to the low-speed ends of the model resistance curves. An extrapolation diagram on these lines is shown in the paper, where the extrapolator corresponds to the Schoenherr line in which the ordinates have been increased by 8 per cent. This modified Schoenherr extrapolator has a slightly steeper slope than the plane friction line, and this slight increase in slope leads to a reduction in the smooth ship prediction and a corresponding increase in the " roughness allowance " in order to balance the measured ship resistance.

The difference between the two methods of prediction is not great and would appear to merit serious consideration, more especially since had the prediction been made for a ship longer than 190·5ft this difference would have been greater.

Analysis on the above lines has also been carried out using the Prandtl-Schlichting formulation for the skin frictional resistance of plane smooth surfaces, viz.

$$C_f = \frac{0{\cdot}455}{(\log_{10} R_n)^{2{\cdot}58}}$$

The evaluation of this formula is very nearly the same as the Schoenherr line and over the range of Reynolds numbers covered by this investigation the former lies 2 to 2½ per cent above the latter.

Both the " two-dimensional " and " three-dimensional " predictions using the Prandtl-Schlichting formulation agree with the corresponding Schoenherr predictions to well within 1 per cent and remarks apply generally as before. The intercept between the two and three-dimensional extrapolators or the form effect on skin friction amounts to 5½ per cent on the Prandtl-Schlichting basis, as compared with 8 per cent for Schoenherr.

A diagram in the paper shows an extrapolation on the Telfer basis. This is similar in principle to Fig. 5, considered under Schoenherr's formulation and remarks apply generally as before, except that Telfer's extrapolator has been used, which is defined as follows :—

$$C_f = 0{\cdot}0012 + 0{\cdot}34\, R_n^{-\frac{1}{3}}$$

It was found that the model results did not align themselves parallel to Telfer's basic extrapolator. According to Telfer they need not necessarily do so, as he has stated that the slope of the extrapolator for geometrically similar models will depend upon the form and proportions of the models. He has always inferred that the slope of the three-dimensional model extrapolator would be greater than his basic two-dimensional extrapolator. The argument behind this was that at low Froude numbers, where wave-making resistance is negligible, the three-dimensional extrapolator would coincide with the basic two-dimensional extrapolator at infinite Reynolds number—that is, both lines would have the same C_f value of 0·0012 at infinite R_n, which is the constant term in the above equation. This does not apply to the " Lucy Ashton " series of models, as the cross curves of constant corresponding ship speed have slightly less slope than the basic Telfer extrapolator.

Nevertheless, the cross curves appear to align themselves as a series of parallel straight lines ; these have been extrapolated to the full scale and comparisons have been made with the measured full-scale resistance. The ship model correlation on this basis is shown in Fig. 7. Remarks here apply as before, except that the roughness allowance is noticeably less than that associated with Schoenherr's prediction. The resulting average roughness allowances which must be used in conjunction with this particular method of extrapolation in order to predict the measured ship resistance for the four naked hull conditions are as follows :—

	Average allowance on C
(i) Sharp seams with red oxide paint	+0·00014
(ii) Faired seams with red oxide paint	+0·00004
(iii) Sharp seams with aluminium paint	+0·00003
(iv) Faired seams with aluminium paint... ...	−0·00003

The smooth ship prediction comes on the average slightly above the faired seams with aluminium paint condition, but this difference amounts to about 1 per cent on resistance ; and it could be said that the prediction agrees with the measured ship resistance in the smoothest condition of faired seams with aluminium paint. Consideration of the roughness records in Section B suggests that this is probably fortuitous for the following reasons. In the faired seams with red oxide condition a positive roughness allowance of 0·00004 is required, and from the relative magnitudes of the amplitudes of the roughness of the red oxide and aluminium paint surfaces, one would expect a slightly reduced but still positive roughness allowance of the same order for the faired seams and aluminium paint condition.

The ship prediction has been effected by extrapolating lines of constant Froude number, whose slope has been defined solely by the range of models tested ; these lines bear little relation to Telfer's extrapolator, apart from the fact that they appear linear on the contracted base of

$R_s - k$. In other words, the ship prediction considered here could not have been obtained from tests on a single model.

Froude's frictional coefficients or the "0" values do not comply with the physical laws of skin frictional resistance, and this precludes the alignment of the ship and model results on a Reynolds number base in the form of extrapolation diagrams.

The principle adopted has been to make Froude predictions from the individual model results in the normal manner and to compare these directly with the ship results. Ship model comparisons on these lines are presented. One set of predictions is based on the model results with trip wire and no corrections have been made for tank boundary restriction, but those shown in Fig. 8 were corrected for the effects of tank boundary restriction and shallow water. The predictions from the various models do not include any percentage allowance for roughness or any other effects.

In Fig. 8 at speeds below about 11 knots there is a wide variation in the predictions from the models and these lie generally above the ship curves, the predictions, in this region being generally greater the smaller the model length. With increasing speed the spread of the different model predictions is appreciably reduced, and with the exception of the 9ft model the curves come together in a narrow band, which follows the smooth ship curve very closely at 11 knots and above. The spread of this band of the model predictions in this region is of the order of 2 per cent, and this speed range would include the service speed of the ship, which is about 12 knots.

The predictions from the 16ft and 20ft models are almost identical ; they are of special interest in that the majority of commercial tests are carried out on models between these lengths. The following table shows the percentage excess of the ship resistance over the predictions from these models at various speeds for the two hull conditions considered :—

Speed, knots	Hull condition	
	Faired seams, aluminium paint, per cent	Sharp seams, red oxide paint, per cent
6	−12	−8
8	−11	−5
10	−6	+1
12	−1½	+4½
14	0	+5½

It is apparent that at 12 knots and above the model prediction agrees with the ship in the smoothest condition (faired seams with aluminium paint) to about 1 per cent and the sharp seams with red oxide condition, which may be regarded as the normal service condition, is about 5 per cent higher.

Correlation of Roughness Allowances with Equivalent Sand Roughness.—Fig. 9 gives a graphical presentation of the frictional resistance of plane surfaces with varying degrees of uniform sand roughness.

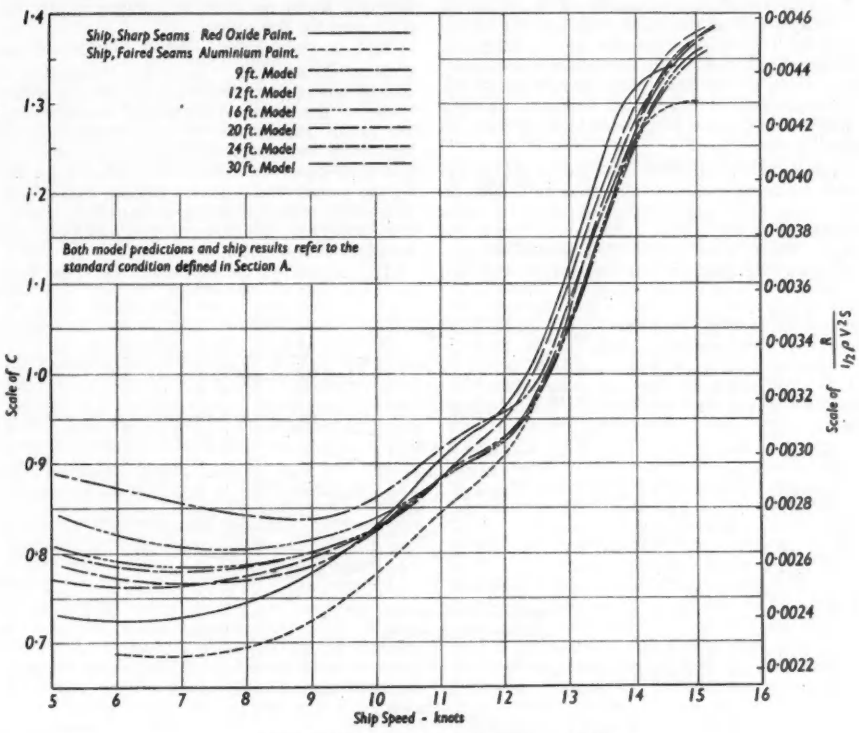
The resistance is given in terms of the usual coefficient C_f on a logarithmic base of Reynolds number for various values of relative sand roughness l/k_s, where l is the length of the surface and k_s is the grain size of the sand which is taken to cover the whole surface. The smooth friction line shown is the Prandtl-Schlichting formulation. It will be noted that for a given value of the relative sand roughness there is a certain Reynolds number below which there is no increase in resistance above the minimum smooth friction line. This insensitivity has been explained by the fact that, in this region, the roughness projections are completely within the laminar sublayer which is always present even in turbulent flow. Above this critical Reynolds number there is a transition region where there is a gradual increase in resistance above the smooth friction line until finally, when the roughness effect is fully developed, the resistance coefficient attains a constant value as shown. At this stage the frictional resistance is varying as the square of the speed and is independent of Reynolds number. On this diagram have been plotted the roughness allowances determined from the ship model correlation, viz. sharp seams with red oxide paint and faired seams with aluminium paint. These roughness allowances have been set up above the smooth friction line shown, and for this purpose they correspond to ship model correlation on the Prandtl-Schlichting basis, but they are almost identical with the roughness allowances on the Schoenherr basis.

Analysis of the roughness records has shown that, geometrically, the nature of clean paint ship roughness differs appreciably from uniform sand roughness, and it is of interest to compare the deduced roughness allowances with the equivalent sand roughness values. The roughness allowances come within the transition region referred to above and the initial rise would appear to be simulated by the rise of the contours of constant sand roughness. It is doubtful whether the roughness allowances would continue to follow the sand roughness contours at higher Reynolds numbers and the marked fall of the roughness allowance at the high-speed end is probably significant in this respect. The approximate average equivalent sand roughnesses for the four hull conditions tested are summarised in the following table :—

Hull surface	l/k_s	k_s in
Sharp seams with red oxide paint	6×10^5	0·0038
Faired seams with red oxide paint	8×10^5	0·0029
Sharp seams with aluminium paint	8×10^5	0·0029
Faired seams with aluminium paint	1×10^6	0·0023

To throw more light on the effect on resistance of the different paint surfaces some tests were carried out on a merchant ship model of 0·706 block coefficient and 18ft 9in long, in which the resistance was measured after the application of red oxide and aluminium paints. There was, however, no perceptible change in resistance between the two paint surfaces nor between these and the normal unpainted wax model surface. A standard trip wire was fitted to the model and before the application of the red oxide paint the surface was given a priming coat of shellac. The aluminium paint was subsequently applied direct to the red oxide surface. Both the paints and the brushes with which they were applied to the model were similar to those actually used on the ship.

It is of interest to consider this resistance behaviour of the paint surfaces on the model in relation to the scale of sand roughness values. For example, it has been shown above that for the ship the red oxide paint surface (with faired seams) corresponds to a relative sand roughness l/k_s of about 8×10^5. Assuming the corresponding model surface would have the same equivalent grain size k_s, the l/k_s value for the model would be reduced in the ratio of model length to ship length, which is roughly 1/10. That is the corresponding l/k_s value for the model would be 8×10^4 approximately. The tests with this model were carried out over the range of Reynolds number 4×10^6 to 8×10^6, and it is interesting to note from Fig. 9 that in this region a surface roughness corresponding to $l/k_s=8\times10^4$ would be expected to have a barely perceptible effect on resistance. Similar remarks apply to the aluminium paint surface. The fact that there was no perceptible difference in resistance between the two paint surfaces on the model scale would appear to be borne out by the sand roughness values.



(Model results corrected for tank-boundary effects.)

Fig. 8—Comparison of Full-Scale Resistance with Froude Predictions from Models

Summary and Conclusions

Correlation of Ship and Model Results.—It is emphasised that, except where stated, all predictions are for the smooth ship and no allowance whatsoever has been made for hull roughness or any other effect ; moreover, the full-scale ship resistance with which the predictions have been compared represents the water resistance only (i.e. wind and air resistance have been eliminated from the results).

Schoenherr's Formulation.—Results for the 9ft, 12ft, 16ft and 20ft models correlate quite well except those for the 9ft and 12ft models at low speeds, which lie slightly high. The results for the 24ft and 30ft models also align themselves on this basis, but only after correction for tank boundary restriction, and in the case of the 30ft model, after a small additional correction for the effect of shallow water on the wave-making resistance.

Subject to the above, all models give within the limits of experimental error a unique smooth ship prediction on the Schoenherr basis. This prediction is generally less than the measured full-scale resistance in all four hull conditions; the roughness allowance in terms of C_f, which must be associated with the former to complete the balance for a given condition is not constant over the speed range, but shows a general rise up to a speed of about 13 knots and then falls away at the higher speeds. In the smoothest ship condition (faired seams with aluminium paint) it will be noted there is a significant roughness allowance of 0·00013, which implies that in this condition the hull surface was not hydraulically smooth. This appears to be

confirmed by comparing this roughness allowance with that for the comparable red oxide surface.

The intercepts (in terms of C_f) between the four ship conditions themselves are reasonably constant over the speed range. The effect of fairing the seams alone corresponds to a roughness allowance of the order of 0·0001. Painting the hull with red oxide paint instead of aluminium paint also corresponds to a roughness allowance of the order of 0·0001. The combined effect of seam fairing and painting with bituminous aluminium paint corresponds to a roughness allowance of 0·00017, which is of the same order as the sum of the two separate effects. The roughness allowance for sharp seams with red oxide paint, which is the normal service condition of the ship, is 0·00030. This is slightly less than, but of the same order as, the allowance of 0·0004 recommended by the American Towing Tank Conference for "clean new vessels" for use in conjunction with predictions on the Schoenherr basis. It should be borne in mind that the shell plate butts were finished flush on the " Lucy Ashton."

Schoenherr predictions from individual models with the usual roughness allowance of 0·0004 on C_f have been compared with the full-scale resistance in the normal service condition of the hull. These show that at low speeds the predictions overestimate the resistance and are about 10 per cent high for all models except the 9ft and 12ft, which are 19 and 14 per cent high respectively in this region. As speed increases these differences decrease and, between 11 and 13 knots, which includes the service speed, predictions for all models come within 1 per cent of the full-scale resistance. At higher speeds the predictions fall some 2 to 3 per cent below the ship resistance, but come together again just above 14 knots. The reason for the overestimate at the lower speeds is to be ascribed largely to the use of a constant roughness allowance over the whole speed range. The detailed ship model correlation has shown that this varies with speed and is generally less at the lower speeds.

Predictions have been made on a modified Schoenherr basis in which an attempt has been made to take into account the form or " three-dimensional " effect on the skin friction. This has been effected on the assumption that the form effect is a constant percentage of the corresponding plane friction and the resistance ordinates of the Schoenherr line were increased proportionately so as to coincide with the low-speed ends of the model curves which were considered to be purely frictional. On this hypothesis the form effect amounts to about 8 per cent and the corresponding extrapolator has a slightly greater slope, which leads to a smooth ship prediction some 4 per cent less on the average. The corresponding increase in the roughness allowances in order to complete the ship model balance is about 0·0001 on C_f. This simple assumption regarding the form effect on skin friction is regarded as tentative, and fundamental work is now being carried out by B.S.R.A. which will shed more light on the problem. Subject to this confirmation it would appear that this process is more logical in that the form effect on skin friction is not treated as residuary or wave-making resistance and is therefore not scaled up according to the law of comparison as at present. The difference between the two methods of prediction is not very great and would appear to merit serious consideration. Moreover, had the predictions been made for a ship larger than 190·5ft the difference would have been greater.

Prandtl-Schlichting Formulation.—The ordinates of this skin friction line and more particularly the slope are very nearly the same as the Schoenherr formulation and lead to almost identical smooth ship predictions. The intercept between the two and three-dimensional extrapolators, or the form effect on skin friction, amounts to 5½ per cent, as compared with the 8 per cent for Schoenherr.

Telfer's Formulation.—When plotted on the contracted base of $R_n^{-\frac{1}{3}}$ as used in this method of extrapolation, the model results do not follow Telfer's basic two-dimensional extrapolator, but align themselves on an extrapolator of noticeably less slope. Extrapolating to the full-size ship using the extrapolator slope suggested by the model results gives a smooth ship prediction which is somewhat higher than Schoenherr's and involves, therefore, correspondingly less roughness allowances.

The smooth ship prediction on this basis comes on the average slightly above but very close to the faired seams and aluminium paint condition. The comparable red oxide paint condition (i.e. with faired seams) shows a significant positive roughness allowance, and the roughness allowances for these two conditions do not appear to correlate with the analysis of the roughness records taken on the two surfaces.

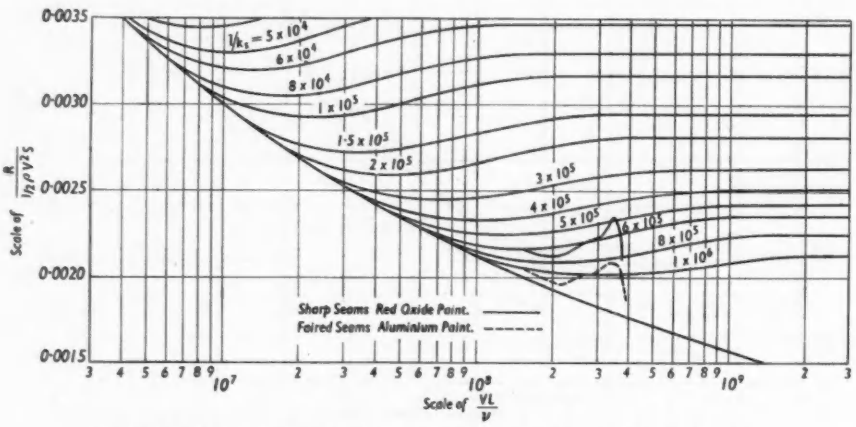


Fig. 9—Correlation of Roughness Allowances with Scale of Uniform Sand Roughness

Froude's Formulation.—Ship predictions have been made from the individual models using the usual " 0 " values in making the skin friction correction between model and ship. Comparison of these predictions with the measured ship resistance shows that : (i) at the lower speeds, below about 11 knots, there is a wide variation in the predictions from the various models ; they generally overestimate the measured ship resistance in this region by amounts varying from 3½ to 20 per cent compared with the smoothest ship condition. The prediction is generally higher the shorter the model. Compared with the sharp seams red oxide condition the corresponding figures are 2 and 18 per cent. The scatter of the predictions in this region is appreciably greater than that for the Schoenherr predictions from individual models. (ii) With increasing speed, the variation in the predictions from the different models is reduced and with the exception of the 9ft model, the predictions follow very closely the measured ship resistance in the faired seams with aluminium paint condition at 11 knots and above. (iii) The predictions for the 16ft and 20ft models are almost identical, and these are of special interest in that the majority of commercial tests are carried out on models between these lengths. At 12 knots and above, which includes the service speed of the vessel, these predictions agree with the measured ship resistance in the faired seams with aluminium paint condition to within about 1 per cent. The ship results for the sharp seams red oxide paint condition, which may be regarded as the normal service condition, is about 5 per cent higher. At lower speeds, however, these predictions are about 12 and 6 per cent high for these two ship conditions respectively. It is of interest to note that the figure of 5 per cent referred to above is of much the same order as the allowance that would normally be used for a clean painted ship surface in predicting resistance from model tests.

Effect of Trip Wires.—The effect of the standard trip wire on the model resistance was generally very small, varying from a maximum of 2 per cent on the 9ft model to a fraction of 1 per cent on the larger models. It was apparent that this particular form was subject to little or no laminar flow. Tests made on the ship with a ⅛in diameter trip wire showed on the average about 3 per cent increase in resistance at low and medium speeds and about 1½ per cent at higher speed. This full-scale trip wire was approximately equivalent in size to the standard 0·032in trip wire used on the 12ft model. The corresponding increases in resistance due to the trip wire measured on this model were approximately 1 to 2 per cent less than those measured on the ship. This correlation between model and ship for the effect of the trip wire is very close, bearing in mind that the percentage effect would be expected to be slightly more on the full scale owing to the relatively smaller resistance of the ship as compared with that of the model.

Analysis of the Records of Hull Surface Roughness.—The analysis of the comprehensive roughness records taken on the two paint surfaces used has shown that : (i) the nature of the surface roughness in the clean painted condition is a complex function of superposed undulations, and the mean amplitude of roughness depends upon the wavelength of the undulation. There appears to be no simple roughness parameter which could be used to define the surface. (ii) For both surfaces, the amplitude of roughness decreases with diminishing wavelength, but the ratio of amplitude to wavelength (or the slope of the undulations) increases as the wavelength is reduced and appears to reach a maximum at a frequency of about 300 undulations per inch. (iii) At lower frequencies of about 1 per inch there is little difference between the two paint surfaces, but at higher frequencies the aluminium paint surface is appreciably smoother than the red oxide and over most of the measurable frequency range the ratio of the amplitudes for the two surfaces is about 2/3. (iv) The maximum values of the ratio of amplitude to wavelengths are about 1/50 for the red oxide paint and about 1/80 for the aluminium paint, which are far removed from the value of 1/2 which would be associated with uniform sand grain roughness ; therefore, the geometrical nature of this paint roughness differs appreciably from sand roughness.

Correlation of Roughness Allowances with Equivalent Sand Roughness.—Roughness allowances deduced from the ship model correlation have been compared with the Prandtl-Schlichting scale of uniform sand roughness for plane surfaces, and it has been possible to assign approximate equivalent sand roughnesses for the four hull surface conditions. Although the curves of roughness allowances appear to follow the sand roughness contours to some extent, it appears doubtful whether this would continue at higher Reynolds numbers, and, further, the geometrical nature of clean paint roughness differs appreciably from sand roughness. For a fuller understanding of the roughness problem more information on these lines is required and especially at higher Reynolds numbers.

Tests with red oxide and aluminium paint on a model in an experiment tank showed no perceptible difference in resistance between the two surfaces and this insensitivity on the model scale is borne out by the sand roughness scale.

General.—In the ship model correlations discussed, the results would be expected to apply particularly to ships of about the same length as the " Lucy Ashton," namely, 190·5ft. Generalisation of the results would depend on confirmation from similar experiments on ships of other lengths, and it is hoped that further investigations on these lines will be carried out.

Industrial and Labour Notes

Industrial Development in Scotland

A White Paper entitled *Industry and Employment in Scotland*, 1952, has been published this week by H.M. Stationery Office (price 2s. 6d.). It is the seventh annual review of the main developments and trends in the economic affairs of Scotland.

The review says that in May of last year the total number of people in employment in Scotland, excluding the self-employed, was about 2,046,000, compared with 2,062,000 in May, 1951, and 2,105,000 in May, 1950. Taking last year as a whole, unemployment was greater than at any time since 1947. It was highest in February when 75,864 people, or 3·6 per cent of the estimated total number of employees, were out of work. The White Paper states that the seasonal improvement in the summer was very much less than usual owing to under-employment and redundancies in some of the consumer goods industries, and the number out of work did not fall below 3·1 per cent of the estimated total number of employees. In the autumn and winter there was a general improvement in the industries which had been affected by the recession, but, it is reported, " it was not enough to offset the normal seasonal increase in unemployment and in December 73,237 people, comprising 46,366 men and boys and 26,871 women and girls, were unemployed." Despite a slight fall in the total level of employment, however, many jobs, especially for skilled men, could not be filled. In the iron and steel industry, for example, there was a serious and persistent shortage of moulders, especially for light castings, and in engineering there was an unsatisfied demand for highly skilled fitters and for turners and machine operators.

One chapter of the review deals with industrial development in Scotland. It says that, in the early part of last year, nearly 7,000,000 square feet of new industrial buildings and extensions were under construction, and that during the year work was started on a further 1,000,000 square feet. In the second half of the year a number of big schemes were completed and by the end of December over 2,000,000 square feet of industrial buildings had been completed and about 5,500,000 square feet were still under construction. By then about 750 industrial buildings and extensions, covering approximately 16,500,000 square feet, had been completed in Scotland since the end of the war. During the year eighty-six industrial development certificates were issued in connection with new industrial building schemes and, as in the preceding year, a very large part of the proposed development was for expansion at existing premises. The review says that about three-quarters was in the heavier industries, including coal mining, metals and metal goods and engineering. At the beginning of last year, 224 manufacturing firms from other parts of the United Kingdom or from abroad were known to have started production in Scotland since 1937, or to be about to do so, and those already in production were employing 51,970 people. Twelve of those concerns, employing about 2300 people, decided during the year to close their Scottish factories, but three other firms from outside Scotland started production there for the first time and three more are expected to do so shortly. At the end of the year firms new to Scotland were employing 51,750 people.

Dealing with the coal mining in Scotland, the White Paper records that the output of saleable deep-mined coal fell from 23,605,200 tons in 1951 to 23,170,800 tons in 1952. Output per manshift overall declined from 22·2 cwt to 21·2 cwt and output per manshift at the face also declined from 52 cwt to 50·4 cwt. This, it is suggested, was due in part to adverse mining conditions at a large number of collieries and in part to the recruitment of inexperienced adult workers and juveniles. Surface drift mines continued to provide a substantial contribution to the output of the Scottish Division of the National Coal Board. At the end of the year thirty-six of these mines were in full production, eleven were in various stages of development, and schemes for driving two others had been approved. The report adds that there was a considerable increase in coal mining manpower in Scotland last year. At the end of the year the number of workers on colliery books was 85,902, compared with 82,175 at the end of 1951, and was higher than at any time since 1940. The average percentage of absenteeism of all workers in the Scottish Division increased slightly from 10·19 to 10·30, and the coal lost by disputes was 375,000 tons, compared with 253,000 tons in 1951.

The Future of Overseas Trade

At the annual meeting of Leyland Motors, Ltd., which was held on March 31st, Mr. C. Basil Nixon referred, in the course of his address as chairman, to the future of British trade overseas. He said that the world need for this country's products was fundamental, but only Governments could engineer the mechanism by which they could be traded, financed and used freely for the well-being of mankind. It was to be hoped, therefore, that recent Commonwealth and international conferences would give some practical leadership and produce beneficial results.

Since midsummer, Mr. Nixon continued, there had been a dramatic change from the sellers' market to a buyers' market. That change had brought home more forcibly than ever before the necessity of increasing efficiency by every means. The change had been brought about by the general recession in trade, continuance of restrictions in many directions, lack of purchasing power, shortage of foreign exchange and a rapid build-up of European competition. With support from their Governments, Mr. Nixon commented, this company's foreign rivals had been able to offer extraordinary credit facilities over periods, in some cases, up to ten years. Such uneconomic practices had to be countered by the United Kingdom Government, either by persuading the countries involved to desist, or by giving British manufacturers tax rebates and comparable export credit guarantees.

Mr. Nixon went on to mention the need for some tax concession to enable industry to replace its plant and machinery on the basis of replacement value, and thereby to remain efficient and to produce economically without increasing its costs and without reducing its quality. This country, he said, could not hope to retain its markets abroad unless industry was freed from to-day's crippling level of taxation. Furthermore, the Government should encourage export volume as opposed to home sales by some sound incentive scheme. The motor industry had already put before the Chancellor of the Exchequer proposals for such a scheme and it was hoped that he would make such provisions in his forthcoming Budget.

The Monopolies Commission

In a written reply to a Parliamentary question last week the President of the Board of Trade stated that he had asked the Monopolies Commission to report on certain practices relating to tenders for the construction of buildings in the Greater London area. In this reference, Section 6 (2) of the Monopolies and Restrictive Practices Act has been used for the first time. This means that the Monopolies Commission—once it has established that the conditions prevailing in the industry are such as to bring it within the scope of the Act—is to report on the " public interest " aspect only of the particular practices specified in the reference.

According to the Board of Trade, these " particular practices " are " communicating to a person other than the person calling for tenders for the construction of a building the amount of any proposed tender for such construction in accordance with any agreement or arrangement " ; and " adjusting the amount of any proposed tender for the construction of a building in accordance with any agreement between the proposed tenderer and anyone other than the person calling for tenders for such construction." Any person or organisation wishing to offer evidence on the subject is asked to write to the Monopolies and Restrictive Practices Commission, 3, Cornwall Terrace, London, N.W.1.

This is the fourteenth subject referred by the Board of Trade to the Monopolies Commission. The Commission's reports on five of the subjects have already been published and its report on matches and match-making machinery has been presented and awaits publication. Reports on non-ferrous metal semi-manufactures and on imported timber are expected to be ready later this year. Besides the requirement, announced recently, for a report on the general effect on the public interest of certain discriminatory trading practices, matters now before the Commission include the printing of woven fabrics, and the production of certain electrical machinery and pneumatic tyres.

Distribution of Primary Nickel

The manganese-nickel-cobalt committee of the International Materials Conference has announced the acceptance by thirteen of its fourteen member Governments of a distribution plan for primary nickel and oxides in the second quarter of this year. The recommended plan has been sent to all the interested Governments for implementation. In this plan, as in those prepared for the last two quarters of last year and the first quarter of this year, there is provision for any nickel allocated to countries participating in the distribution, but not used by them, to become available for purchase by consumers in the U.S.A. and in other countries.

The total production estimate of primary nickel and oxides for the present quarter, excluding Japanese output, shows an increase of about 200 metric tons nickel content over the figure for the first quarter, which is said to be less than one-half of 1 per cent. About 500 tons of nickel oxides produced in the U.S.A. Nicaro plant in Cuba during the second half of last year, in excess of the original estimate for that period, have been included in the second quarter's distribution. The quantity recommended in the plan for distribution amounts to 37,800 metric tons nickel content.

The Austin Works Dispute

Before the House of Commons rose for the Easter recess on Thursday of last week, the Minister of Labour, Sir Walter Monckton, stated that he had decided to appoint a court of inquiry to investigate the causes and circumstances of the dispute involving vehicle builders at the works of the Austin Motor Company, Ltd., Birmingham. This dispute, which began on February 17th and which led to a stoppage of work, was stated to have arisen on account of " alleged discrimination against a shop steward when other redundant workers were being re-engaged." A fortnight ago the company stated that it had discharged 1583 members of the National Union of Vehicle Builders who were then still on strike. The executive committee of the union then asked the Minister of Labour if he would set up a court of inquiry.

In his statement in the House of Commons, the Minister said that, having had a request from the union concerned to appoint a court of inquiry, he thought it right to give the management an opportunity of expressing a view. Whilst the management did not think the facts needed to be ascertained, it welcomed the opportunity of seeing an independent body going into the matter. The Minister added that it was not a case, in either instance, of asking for conditions because the consent of neither side was required.

The members of the court of inquiry are Sir John Forster, Q.C., president of the Industrial Court, who will act as chairman ; Mr. A. J. Espley, formerly managing director of Timothy Whites and Taylors, Ltd., and Mr. A. G. Tomkins, general secretary of the National Union of Furniture Trade Operatives.

Notes and Memoranda

Air and Water

PATROL BOAT "GAY CENTURION."—A fast patrol boat, which is of wooden construction and has a length of 72ft 2in by 19ft 8in beam, was named "Gay Centurion" on March 26th at the Hampton-on-Thames yard of John I. Thornycroft and Co., Ltd.

TURBO-ELECTRIC MACHINERY.—The propeller motor which forms part of the 7500 s.h.p. turbo-electric machinery, under construction by the British Thomson-Houston Company, Ltd., for the oil tanker "Helix," has been sent by road to Newcastle upon Tyne. The unit, weighing 100 tons, was then shipped down river by the floating crane "Titan" to the shipyard of Swan, Hunter and Wigham Richardson, Ltd., where the vessel is fitting out.

THOMAS GRAY MEMORIAL TRUST.—Under the Thomas Gray Memorial Trust, the Council of the Royal Society of Arts offers, in 1953, a prize of £50 for an essay not exceeding 7500 words in length, on the subject "The Improvement of Cargo Handling Appliances on Board Ship and on the Quayside; with Special Reference to the Need for Self-sufficient Arrangements in Times of Emergency and the Over-riding Consideration of Keeping Costs Low." The offer is open to a professional seafarer of the British Merchant Navy, of British nationality, who is serving afloat or if now ashore was last regularly serving afloat no longer ago than January 1, 1951. The essay, typed in English, must be submitted under a pseudonym and accompanied by the author's name and address in a sealed envelope, not later than December 31, 1953.

NEW AIR FERRY SERVICES.—Following the granting of licences by the Ministry of Civil Aviation, Silver City Airways will operate two new air ferry services for passengers, cars and cycles with effect from May 15, 1953. The new London-Le Touquet service will operate with Bristol "Superfreighter" aircraft seating twenty passengers and accommodating up to three cars and a miscellany of cycles and motor-cycles. Initially the forty-minute, 91 mile route from Gatwick to Le Touquet will be flown twice a day. As B.E.A. has discontinued its London-Le Touquet passenger service, the new air ferry will serve as a replacement. The passenger fare will be £7 4s. return and vehicle charges will be £10 10s. single for a small car and 7s. 6d. for a bicycle. The air ferry between Eastleigh Airport, Southampton, and Bembridge Airport on the Isle of Wight, will provide up to twenty-four services a day and the 21 mile flight will take nine minutes. The application to operate this service was vigorously opposed by British Railways and the licence was only granted after strong representations had been made by local interests in the Island. Fares will be from £3 2s. 6d. single for cars, 3s. for a pedal-cycle and 13s. 6d. for passengers.

Miscellanea

WIRE ROPE SPLICES.—A booklet has been issued by the Wire Rope Advisory and Technical Service Department of British Ropes, Ltd., Doncaster, dealing with the terminal splicing of wire ropes. The splices discussed are a five tuck splice, an end splice in a 17×7 and a 34×7 multiple stranded rope, and the fitting of a Bordeaux connection.

THE CHEMICAL SOCIETY.—At the annual general meeting of the Chemical Society held in Burlington House on March 27th, the following elections of the Council were declared:—Vice-president, Professor R. D. Haworth; Members of Council, Professor F. Bergel, Professor M. J. S. Dewar, Dr. I. J. Faulkner, Professor Brynmor Jones, and Dr. A. I. Vogel.

THE SWINDEN LABORATORIES.—We have received from the United Steel Companies, Ltd., 17, Westbourne Road, Sheffield, an illustrated brochure describing the organisation and activities of the central research and development department, which is housed at the Swinden Laboratories, Rotherham. These laboratories, which were completed last year, were the subject of an article published in our issue of August 1, 1952.

FOREMEN'S TRAINING COURSE.—A training course for foremen and women supervisors is to be held by the Industrial Welfare Society, at 48, Bryanston Square, London, W.1, from April 20th to 24th inclusive. The course is restricted to a tutorial group of thirty in order to give ample opportunity for practice and personal guidance. Full particulars may be obtained from the Industrial Welfare Society at the address given above.

THE CONTROL OF INDUSTRIAL DUST.—A new edition of its handbook on the control of the dust hazard in industry has just been published by John Yuill (Metal Works), Ltd., Scottish Industrial Estate, Hillington, Glasgow, S.W.2. In addition to dealing in detail with the firm's filters and filtering equipment this book describes the types and causes of dust, its classification, control methods, the treatment of fumes, &c. It incorporates much information and data which will be of value to those concerned with dust problems in industry.

THE IRON AND STEEL INSTITUTE.—It is announced that the eighty-fourth annual general meeting of the Iron and Steel Institute will be held in London on April 30th and May 1st next. At the first session of the meeting the following presentations will be made:—The Bessemer Medal for 1952 to Mr. R. Mather; the Sir Robert Hadfield Medal to Mr. W. E. Bardgett; the Andrew Carnegie Silver Medal to Dr. E. T. Turkdogan, and the Ablett Prize to Dr. S. A. Burke and Mr. G. A. Sparham. The new president, Mr. James Mitchell, will also be inducted and he will give his presidential address. The special meeting which was to have been held on February 18th to discuss recent developments in the U.S.A. in the manufacture and use of boron bearing steels is now to be held on Wednesday, April 29th at the offices of the Institute. This meeting has been arranged by the Institute at the suggestion of the Ministry of Supply, acting in conjunction with the Organisation for European Economic Co-operation. Dr. H. Rohl, of United States Steel Corporation, and Mr. H. B. Knowlton, of International Harvester Company, will present papers, and a paper giving the results of certain British research will be presented by Mr. R. Wilcock, of the United Steel Companies, Ltd.

NATIONAL COAL BOARD APPOINTMENT.—In addition to its own research establishments at Stoke Orchard and Isleworth, the National Coal Board has extensive interests in several research associations and also sponsors projects at a number of universities and with commercial firms. This work will in future be directed by Mr. A. Whitaker, who has been appointed Director of Extramural Research and will be responsible to Dr. W. Idris Jones, the Director General of Research at the N.C.B. headquarters.

INSTITUTE OF INDUSTRIAL SUPERVISORS.—At the annual general meeting of the Institute of Industrial Supervisors, Sir Percy H. Mills, the managing director of W. and T. Avery, Ltd., was re-elected president for a further year. Mr. J. K. Evans, the labour officer of I.C.I. Metals Division in Birmingham was also elected chairman of the Institute council. Six vice-presidents were elected, the office being accepted by Sir Anthony Bowlry, Sir Hugh Beaver, Sir Patrick Hamilton, Mr. A. B. Waring, Mr. F. J. Burns Morton and Mr. E. O. Seits.

COMPETITION FOR A PAPER AND A FILM ON THE OXY-ACETYLENE FLAME.—Particulars have been issued by the Commission Permanente Internationale de l'Acétylène, de la Soudure Autogène et des Industries qui s'y Rattachent, for two international competitions, one for a paper and one for a film on the applications of the oxy-acetylene flame. The paper must deal with one or several practical applications of the oxy-acetylene or air-acetylene flame, such as welding, soldering or brazing, bronze welding, oxygen cutting, surface hardening, building up, metal spraying, heat-treatments, &c. It must be unpublished or not have been published before January 1, 1953. The film will have to cover the same broad field and it can be made up in whole or in part of cuttings from films already in existence. Full details and rules of the competitions can be obtained from the Secretary General of the Commission, 32, Boulevard de la Chapelle, Paris 18.

A WORKS EXHIBITION.—A permanent exhibition has been laid down at the Stockton-on-Tees works of the Power Gas Corporation, Ltd., and Ashmore, Benson, Pease and Co., Ltd., in order to show visitors the many and varied classes of work in which the firms specialise. The exhibition hall is arranged in nine sections, in each of which, by means of diagrams and photographs, a particular aspect of activity is shown. In the various sections excellent photographs arranged on mahogany panels show some typical works carried out in connection with blast furnaces, chemical plant, gas-making plant, special fabricated vessels and mechanite castings, dust control and heat exchanger plant, project and field engineering and erection of plant. One section shows typical products of Rose, Downs and Thompson, Ltd., of Hull, an associate company. This exhibition hall is built on the roof of the main office block and from a loggia outside a complete view of the works is obtained with the site and first buildings of the new 100-acre South Works in the distance.

PREFABRICATED ALUMINIUM ALLOY BUILDINGS.—The advantages of standardisation and unit construction combined with a maximum choice of building sizes are claimed for a new range of light alloy buildings made by Chamberlain Industries, Ltd., Staffa Works, Leyton, London, E.10. The basis of the design is a two-pinned portal frame, of which there are two standard sizes, 30ft span by 12ft high to eaves, and 40ft span by 12ft high to eaves. Each portal frame itself consists of two standard wall units and two rafter units. To obtain greater spans and wall heights, a knuckle unit is used between the wall and rafter members at the eaves. This knuckle unit is not a fixed size but when used in conjunction with the other components it provides a portal frame of the dimensions required within certain fixed limits. The sizes of buildings which can be constructed by this method range from 30ft to 56ft spans, with wall heights from 12ft to 15ft. The length of the building is in multiples of 10ft with a special bay at the end to make up any required size. Cladding may be either asbestos cement sheets or aluminium alloy sheeting.

GEAR LUBRICATION.—We have received from the Vacuum Oil Company, Ltd., a copy of a brochure entitled "Gear Lubrication," which is No. 6 in the Vacuum technical series. There is a short note upon the evolution of gears, followed by a section dealing with the fundamentals of gear operation. In this are discussed items such as friction wheels, shaft speeds and the types of gears, including illustrated notes upon spur, stepped, helical, worm, bevel, and hypoid gears. Tooth forms for the various gears are dealt with and there are brief references to tooth systems, contact, and angle of pressure. Under the heading "the need for lubrication" the booklet touches upon the subjects of pitting, abrasion, scoring, scuffing and various failures. The next two sections are concerned with the various methods of lubricating enclosed and open gears, and each section enumerates the factors influencing lubrication, discusses the method of application, temperature and oil characteristics. Oils suitable for industrial gears are listed, and charts contain the recommendations of oil for enclosed and open gears linked with pinion speed, load and method of application.

Personal and Business

MR. J. T. RYMER has been appointed managing director of Sentinel (Shrewsbury), Ltd.

MR. C. E. PROSSER has been appointed chairman of the Metals Division of Imperial Chemical Industries, Ltd., in succession to Mr. H. E. Jackson, who is retiring.

SLOUGH ESTATES (LONDON), Ltd., 16, Berkeley Street, W.1, states that the manufacture of the "Monarch" tractor has now been taken over by Singer Motors, Ltd.

SOLVENT PRODUCTS, Ltd., Dagenham Dock, Essex, announces that, as part of an internal reorganisation in the Distillers Company, Ltd., group, it has ceased to trade as a separate company.

MR. G. R. WEIR, assistant director, Sea Transport Division of the Ministry of Transport, has been appointed Deputy Director of Merchant Shipbuilding and Repairs at the Admiralty.

THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION states that Mr. C. N. Kington, chief engineer and administration officer at the Sheffield laboratories, has been appointed, in addition, group manager.

TURNER AND NEWALL, Ltd., states that Mr. J. L. Collins has retired from the post of secretary, but will continue to serve as the company's legal adviser. Mr. A. D. N. Jones has been appointed secretary.

HEENAN AND FROUDE, Ltd., Worcester, states that Mr. Charles L. Hill, deputy chairman, has been elected chairman in succession to the late Mr. A. P. Good. Mr. F. J. Fielding, managing director, has been appointed deputy chairman.

SHEEPBRIDGE ENGINEERING, Ltd., Chesterfield, states that, following the transfer of its group sales office from London to Chesterfield, Mr. M. M. Hallett, formerly research and development manager, has been appointed director of sales.

MR. JOHN NEILL and Mr. M. Woosnam have resigned from the board of North Eastern Marine Engineering Company (1938), Ltd. New directors of the company are Mr. E. Dale, Mr. A. H. W. Dawson, Mr. C. Gresty, Mr. G. L. Hunter, Mr. J. M. Ireland, Mr. F. W. Matthews and Mr. A. Storey.

HENRY MEADOWS, Ltd., Wolverhampton, announces the following appointments:—Mr. E. H. L. Cooper, general works manager; Mr. J. R. Threlfall, production manager; Mr. G. Metcalfe, production controller; Mr. D. E. Mallet, chief inspector, and Mr. H. D. Prescott, assistant chief inspector.

THE FEDERATION OF BRITISH INDUSTRIES announces the resignation of Mr. Bertram White from the position of technical director, in order to take up an appointment in industry. Dr. J. E. G. Harris, who has recently retired from Imperial Chemical Industries, Ltd., has become acting technical director of the F.B.I.

THE CONSOLIDATED PNEUMATIC TOOL COMPANY, Ltd., 232, Dawes Road, London, S.W.6, states that, at his own request, Mr. J. A. Owen has retired from the position of managing director, after completing fifty years in the company's service. He will continue as a director and technical consultant. Mr. Norman Readman has been appointed managing director.

CROMPTON PARKINSON, Ltd., announces the resignation of Mr. Albert Parkinson from his position of joint managing director. Mr. Parkinson continues as chairman of the company. Crompton Parkinson, Ltd., also announces that Mr. F. H. Beasant is leaving the company to join the board of the Anti-Attrition Metal Company, Ltd., and that Mr. Frank Foster has been appointed general manager of the "Cyc-Arc" stud welding division.

Launches and Trial Trips

KING ARTHUR, cargo liner; built by Harland and Wolff, Belfast, for King Line, Ltd.; length between perpendiculars 435ft, breadth moulded 59ft, depth moulded to shelter deck 39ft 9in, gross tonnage 5883; two complete steel decks, seven water-tight bulkheads, four main cargo holds and deep tank; one 50-ton derrick, one 25-ton derrick, four 10-ton derricks and six 5-ton derricks; Harland-B. and W. single-acting, four-stroke, diesel engine, six cylinders 740mm diameter by 1500mm stroke, 115 r.p.m.; three 125kW diesel-driven generators.—Trials, March 20th.

LA HACIENDA, cargo liner; built by Swan, Hunter and Wigham Richardson, at the Neptune Shipyard for Buries Markes, Ltd.; length between perpendiculars 435ft, breadth moulded 60ft, depth moulded to shelter deck 39ft, deadweight 10,000 tons on 26ft 5in draught; service speed 13·375 knots; five cargo holds, MacGregor steel hatch covers, ten derricks to lift 5 tons and six to lift 10 tons; Swan, Hunter-Doxford oil engine, equipped to burn heavy boiler fuel, four cylinders 670mm diameter by 2320mm combined stroke, 4400 b.h.p. at 115 r.p.m.; three 175kW generators driven by Mirrlees, Bickerton and Day seven-cylinder oil engines, Cochran waste heat boiler.—Trials, March 23rd.

CITY OF YORK, passenger liner; built by Vickers-Armstrongs, Ltd., at the Walker Naval Yard for Ellerman Lines, Ltd.; length between perpendiculars 500ft, breadth moulded 71ft, depth moulded to upper deck 41ft, displacement 19,640 tons, load draught 28ft 6in., deadweight 11,300 tons; three complete decks, seven watertight bulkheads, five cargo holds, 106 passengers; two Hawthorn-Doxford oil engines, each has six cylinders, 670mm diameter by 2320mm combined stroke, arranged to burn heavy fuel, total b.h.p. 12,650 at 115 r.p.m., two thimble-tube boilers, three 400kW diesel-driven generators, service speed 16·5 knots. Launch, March 30th.

British Patent Specifications

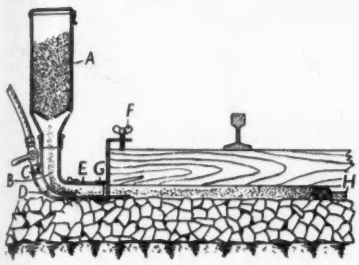
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgement is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

RAILWAY ENGINEERING

688,503. December 4, 1950.—BEDDING RAILWAY SLEEPERS, Auguste Scheuchzer, route d'Oron, Lausanne, Switzerland.

The invention relates to a method of correcting the differences of level in the bedding of sleepers, particularly those resting on a ballast bed. By means of a pressure jet a quantity of coarse gravel is projected between the sleeper (which is first raised) and the ballast. The gravel mixture fills the space and supports the sleeper at its correct level. A



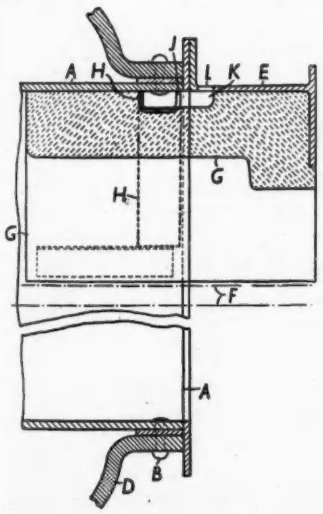
No. 688,503

description is given in the specification of the rail truck complete with an engine-driven air compressor, and air and gravel storage vessels, which is used. As the drawing shows, the gravel storage vessel *A* is connected with a curved channel *B*, to which is attached an air channel *C*. This channel is divided by a central partition *D*, so as to give two flattened orifices which promote effective projection of the gravel. A control valve is provided on the air pipe, and a control lever on the gravel vessel regulates discharge. The final injection nozzle *E* can be made to suit various types of rail and sleeper attachments. To prevent an escape of air and gravel, a rubber sleeve *G* is used at the end of the nozzle. To limit the flow, a retaining bar *H* is placed near the far end of the sleeper.—*March* 11, 1953.

FURNACES

688,208. July 19, 1949.—JOINTS FOR BOILER FLUES, John Thompson (Triumph Stokers), Ltd., 85, Kirkstall Road, Leeds, 3; Bernard Marks, 343, Dudley Road, Wolverhampton, and Francis Edward Stanton, 60, Rosemary Crescent West, Goldthorn Park, Wolverhampton.

In the drawing the flue *A* of a shell boiler is riveted at *B* in the usual way to a flange on the shell *D* which embraces the flue. An extension flue *E* secured to the boiler structure projects for a short distance above the grate, shown by the chain lines *F*. Within



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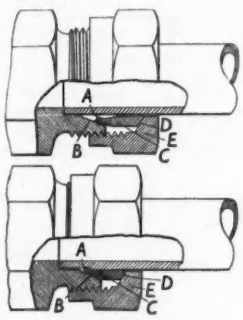
the boiler flue and the extension flue is a refractory arch *G* which extends over the upper semi-circumference of these parts, affording protection to the upper arc of rivets holding the joint between the flue and the boiler shell. The remaining arc of this joint is normally below grate level, and is therefore not so liable to be exposed to the direct flame of the fire. In order to provide additional protection to the joint in the event of partial or complete collapse of the refractory arch, a channel section member *H* is arranged to enclose those rivets around the circumference of the flue *A* which would be exposed to the direct action of the flame. The channel member is relatively shallow and provides a duct through which air or other fluid can be circulated for cooling purposes. Thus, for example, apertures *J* may be formed in a flange wall of the channel which communicate by way of short ducts *K* formed or embedded in the refractory material with radial ports *L* opening through the extension flue *E* and communicating with the surrounding atmosphere. Air can thus be circulated through the channel by natural convection to provide a cooling action for the rivet heads.—*March* 4, 1953.

TUBE AND PIPE COUPLINGS

688,744. June 6, 1951.—SEALING MEANS FOR PIPE UNIONS, Hans Kreidel and Hans Kreidel Junior, Moritzstrasse 6, Wiesbaden, Germany.

The upper view of the drawing shows a pipe connection made in accordance with the invention, the special gasket ring being shown in its preliminary form, assembled in the joint. The lower view shows the ring in its final form with the front cutting and sealing edge penetrating the pipe. The gasket ring,



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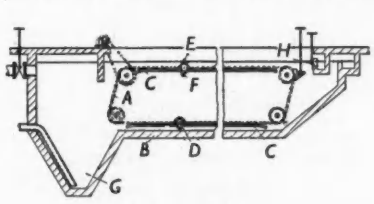
which is made of specially hard metal, has a front cutting and sealing edge *A* and it is coned to fit the taper bore of the union ring *B*. The middle portion of the gasket ring *C* has converging faces towards the front whilst the rear portion forms a tail *D*, designed to receive and transmit the thrust of the nut *E*, when the joint is tightened up. The shape of the gasket ring is such that the amount of force required to make the joint is comparatively small. The specification also shows the design of gasket rings for various duties.—*March* 11, 1953.

CIVIL ENGINEERING

688,697. March 20, 1950.—SCRAPER MECHANISMS FOR CLARIFYING TANKS, William E. Farrer, Ltd., Crown Works, Welby Road, Hall Green, Birmingham, 28, and Gerard Michael Rooke, of the company's address.

The invention provides scraper mechanisms for use in sewage, industrial, sedimentation or clarifying tanks. As the drawing shows, there are two power-driven chains *A* situated at opposite sides of the tank *B*, so that one part of each chain is near the floor of the tank and the other part near to the free surface of the liquid in the tank. Each horizontal portion



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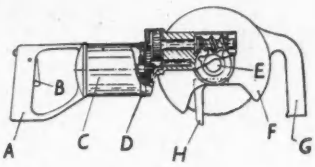
of the chain is supported on stationary skids or rollers *C*. Between the chains there is arranged at least one scraper carrier rigidly secured at its ends to the chains. The carrier is buoyant and is constructed from a closed metal tube *D*. Along one side of the carrier is a scraper blade *E* or a longitudinal series of blades made from rubber, or leather. A balancing mass *F* is secured to the side of the carrier opposite to the blade or the point of attachment is such that the carrier itself counterbalances the weight of the scraper. In action the scraper when moving along the floor of the tank sweeps the deposits into a collecting trough *G* at one end and when moving along the surface of the liquid sweeps the floating matter into a duct *H* at the other end of the tank.—*March* 11, 1953.

I. WORKSHOP TOOLS AND APPLIANCES

688,661. October 4, 1950.—HAND-GUIDED ELECTRICALLY DRIVEN METAL CUTTING SAW, Otto Baier, of Otto Baier K.—G., of Murgtalstrasse 24, Stuttgart-Münster, Germany.

In the drawing of the saw, the handle *A*, which has a switch *B*, is connected to the motor casing *C*. To the front cover of this casing is screwed the body *D* of the reduction gear to form a composite unit. The



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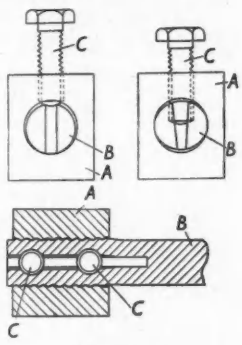
reduction gear, as shown, comprises two pairs of pinions and a worm gear mounted on the saw shaft *E*. The circular saw is surrounded by a shield, partly cut away at the periphery, to which the cover *F* is attached. The cover is shaped at its outer end to form another handle *G*. There is also affixed to the casing the support *H*.—*March* 11, 1953.

ELECTRICAL ENGINEERING

688,280. April 14, 1950.—JOINTS FOR CONDUCTORS, The English Electric Company, Ltd., Queens House, 28, Kingsway, London, W.C.2. (*Inventors: Henry Simmonds, Vernon Brandon Betteridge, and Percy Edward White.*)

The invention has reference to making joints between a solid conductor and a terminal block having an aperture into which the conductor is inserted and in which it is clamped by one or more screws or bolts. From the drawing it will be seen that a brass terminal block *A* has a bore to receive the end of a circular copper busbar *B*. A pair of clamping screws *C* threaded in the terminal block normal to the axis of the bore is provided. The end of the busbar is slotted by milling, and the width of the slot is approximately two-thirds of the root diameter of the screws. The conductor is inserted into the bore and the screws are then tightened. On tightening the screws the end of the busbar is first forced against the



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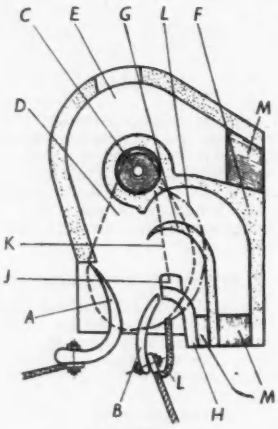
opposite side of the bore as shown in the top left-hand view, and the screws then begin to cut into the metal of the busbar, forcing the adjacent edges of the slot outwards so that the two sides of the busbar are forced into contact with the sides of the bore as shown in the upper right-hand and lower views. In practice the screws are tightened until their ends extend about halfway across the diameter of the busbar and in so doing the slot is deformed from one having parallel sides to a somewhat tapering shape, as shown. With this arrangement in theory, two line contacts will be produced along the sides of the bore, but the area of contact is still further increased by making the walls of the bore of a configuration different from that of the busbar. Thus if the busbar is of smooth circular cross section the walls of the bore may be provided with circumferentially extending grooves as shown in the lower view.—*March* 4, 1953.

688,705. May 26, 1950.—ARC CHAMBERS OF CIRCUIT BREAKERS AND CONTACTORS, Etablissements Merlin and Gerlin, Rue Henri Tarze, Grenoble, Isère, France (*Inventor: Georges Bouvier*).

This invention relates to circuit breakers and contactors in which the extinction of the arc is achieved by a "magnetic blow-out." The drawing shows a circuit breaker in which the blow-out coil is directly within the arc chamber. In the drawing *A* is the

fixed contact, *B* the moving contact of the circuit breaker, *C* is the blow-out coil, and *D* one of the two metallic side plates of the magnetic blow-out circuit. The arc chamber *E*, according to the invention, is provided with curved partitions *F*, *G* and *H* of a shape such that they cut nearly perpendicularly the path of the arc in the different position which, in the absence of the partitions, it would assume due to the magnetic blow-out. Thus, the lengthening and the division of the arc into small lengths prior to its extinction become more efficient. At the same time, the shape of the partitions provides for an exhaust of the hot gases produced by the arc towards an area where they are least disturbing, towards the right-hand side. The blow-out coil *C* is normally out of circuit and inserted by the arc itself into the electrical circuit closed by the striking arc. This is achieved by means of an auxiliary electrode : an arc horn *J* located so as to receive one of the roots of the arc. This



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horn is connected by a conductor *K* to one of the terminals of the coil *C*, whilst the other terminal is connected by the conductor *L* to the movable contact *B*. On parting of the contacts an arc strikes between the fixed contact *A* and the movable contact *B*. Due to the U-shaped magnetic circuit formed by the metallic plates *D* and the core of the coil *C*, the root of the arc on contact *B* is transferred from the latter to the horn *J*. The current thereupon flows through the following circuit : the fixed contact *A*, the arc, the arcing horn *J*, the conductor *K*, the blow-out coil *C*, the conductor *L*, and the movable contact *B*. The blow-out coil *C* is then inserted into the circuit and extinguishes the arc by blowing it against the partitions *E* and *F*, whereby it is considerably lengthened and cut into small portions. The extinction occurs therefore in best conditions and very quickly. Stacks of small cooling plates *M* are inserted between the partitions and the walls of the arc chamber in such a way that the air, heated and ionised by the arc, will also exhaust through the stacks, whereby it is cooled so that the exterior effects caused by the arc are considerably minimised.—*March* 11, 1953.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

CLEVELAND INSTITUTION OF ENGINEERS

Mon., April 13th.—Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "Acid Burdening Blast Furnace Performance at Corby," A. Stirling, 6.30 p.m.

ELECTRIC RAILWAY SOCIETY

Sat., April 11th.—Fred Tallant Hall, 153, Drummond Street, London, N.W.1, Film Show, 3 p.m.

ELECTRICAL ASSOCIATION FOR WOMEN

Wed., April 15th.—Connaught Rooms, Great Queen Street, London, W.C.2, Twentieth Annual General Meeting, 10.30 a.m.

ENGINEERS' GUILD

Thurs., April 23rd.—ORDINARY MEETING : Caxton Hall, Westminster, London, S.W.1, Discussion on "Freedom in Engineering," A. Floyd, 6 p.m.

HULL CHEMICAL AND ENGINEERING SOCIETY

Fri., April 24th.—Church Institute, Albion Street, Hull, Annual General Meeting, 7.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

To-day, April 10th.—HUDDERSFIELD GROUP : Electricity Showroom, Market Street, Huddersfield, Annual General Meeting, 7.15 p.m.

Mon., April 13th.—SHEFFIELD CENTRE : Medical Library, The University, Western Bank, Sheffield, "Horticultural Applications of Light," A. E. Canham, Annual General Meeting, 6.30 p.m.

Tues., April 14th.—LONDON SESSIONAL MEETING : Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, "Sports Lighting," M. W. Peirce, 6 p.m.

Wed., April 15th.—N. LANCASHIRE GROUP : Chamber of Commerce, 49a, Fishergate, Preston, Annual General Meeting, 7.15 p.m.

Fri., April 17th.—BIRMINGHAM CENTRE : "Regent House," St. Philip's Place, Colmore Row, Birmingham, "Discharge Lamps for Particular Purposes," E. H. Nelson, 6 p.m.

Tues., April 21st.—LIVERPOOL CENTRE : Merseyside and N. Wales Electricity Board's Service Centre, Whitechapel, Liverpool, 1, "Shop Window Lighting," A. W. Jervis, 6 p.m.

INCORPORATED PLANT ENGINEERS

Tues., April 14th.—E. LANCASHIRE BRANCH : Engineers' Club, Albert Square, Manchester, "Vibration in Buildings and Structures," Mr. Dedass, 7.15 p.m.——LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, "The Maintenance of Process Plants," G. C. Allfrey, followed by Discussion, 7 p.m.

Wed., April 15th.—WESTERN BRANCH : Grand Hotel, Bristol, "The Generation of Industrial Power from Process Steam," E. G. Ritchie, 7.15 p.m.——KENT BRANCH : Bull Hotel, Rochester, "Applications of Hydraulics," D. V. Rowles, 7 p.m.

Thurs., April 16th.—BLACKBURN BRANCH : Chamber of Commerce, Richmond Terrace, Blackburn, "An Approach to Maintenance," M. Brookes, 7.30 p.m.

Mon., April 20th.—LIVERPOOL AND N. WALES BRANCH : Radiant House, Bold Street, Liverpool, "The Engineer and the Brewing Industry," G. W. Campbell, 7.15 p.m.

Tues., April 21st.—GLASGOW BRANCH : Engineering Centre, 351, Sauchiehall Street, Glasgow, Film, "Mobile Mechanical Handling Plant," 7 p.m.——HERTFORDSHIRE DISCUSSION GROUP : Peanen Hotel, St. Albans, "Industrial Lighting," W. S. Veness, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

To-day, April 10th.—TEES-SIDE BRANCH : Head Wrightson and Co., Ltd., Teesdale Ironworks, Thornaby-on-Tees, Annual General Meeting, followed by T.S.35 Film and Report, "Flow of Metal," F. Hudson, 7.30 p.m.

Sat., April 11th.—E. MIDLANDS BRANCH : College of Arts and Crafts, Derby, Annual General Meeting, followed by a Short Paper Competition, 6 p.m.——LANCASHIRE BRANCH : Engineers' Club, Albert Square, Manchester, Annual General Meeting and John Wilkinson Memorial Medal Presentation, to be followed by the Winning Paper in the Short Paper Competition and "Is Mechanisation Worth While ?" J. Gardom, 3 p.m.——NEWCASTLE BRANCH : Neville Hall, Westgate Road, Newcastle upon Tyne, Annual General Meeting, 6 p.m.——WEST RIDING OF YORKSHIRE BRANCH : Technical College, Bradford, Prize Winning Paper in the S. W. Wise Memorial Competition, 1952–53, 6.30 p.m.

Mon., April 13th.—SHEFFIELD BRANCH : College of Commerce and Technology, Department of Engineering, Pond Street, Sheffield, "Internal Stress in Castings," M. H. Hallet, followed by Annual General Meeting, 7.30 p.m.

Tues., April 14th.—COVENTRY AND DISTRICT STUDENTS' SECTION : Technical College, Room A5, Coventry, Annual General Meeting, followed by Film Show, "Production of Castings for National Engines," "Job 99," 7.15 p.m.

Tues., April 21st.—EAST ANGLIAN SECTION : Central Hall, Public Library, Ipswich, Annual General Meeting, 7 p.m.

Wed., April 22nd.—BIRMINGHAM BRANCH : James Watt Memorial Institute, Great Charles Street, Birmingham, Annual General Meeting, "The Production of Match Plates by the Aluminium Pressure Cast Method," D. H. Potts, 7.15 p.m.

INSTITUTE OF ECONOMIC ENGINEERING

Fri., April 17th.—George Hotel, Church Lane, Kingsbury, London, N.W.9, "How Big is Too Big," A. W. Willsmore, 7 p.m.

INSTITUTE OF MARINE ENGINEERS

ues., April 14th.—85, Minories, London, E.C.3, "New Designs of Large Two-Stroke Marine Diesel Engines," W. A. Kilchenmann, 5.30 p.m.

INSTITUTE OF NAVIGATION

Fri., April 17th.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "The Use of Radar for Preventing Collisions at Sea," F. J. Wylie, 5 p.m.

INSTITUTE OF PETROLEUM

Tues., April 21st.—26, Portland Place, London, W.1, Presidential Address, "Two Oilfields in Northern Iraq, H. S. Gibson, 6 p.m.

Wed., April 22nd.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, Symposium on "The Engine Testing of Lubricating Oils," 2.30 p.m.

INSTITUTE OF REFRIGERATION

Tues., April 21st.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, "An Analysis of the Factors Affecting Performance of Small Compressors," W. B. Gosney, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., April 13th.—SCOTTISH CENTRE : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Carburation," L. J. Spencer, 7.30 p.m.

Tues., April 14th.—MIDLANDS CENTRE : Crown Inn Broad Street, Birmingham, Annual General Meeting, followed by Film Show, 7.30 p.m.

Wed., April 15th.—N.W. CENTRE : Victoria Hotel, Wigan, Centre Dinner, Annual General Meeting, followed by Social Evening, 6.30 p.m.

Thurs., April 16th.—YORKSHIRE CENTRE : Hotel Metropole, King Street, Leeds, Annual General Meeting, 7.30 p.m.

Tues., April 21st.—EASTERN CENTRE : Marshalls Airport, Cambridge, Annual General Meeting, 7 p.m.

INSTITUTE OF WELDING

To-day, April 10th.—BIRMINGHAM BRANCH : James Watt Memorial Institute, York House, Great Charles Street, Birmingham, 3, Annual General Meeting, Technical Films, 7 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Tues., April 21st.—INFORMAL MEETING : Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Farm Transport, Including Loading and Unloading," 2.15 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Sat., April 11th.—N.W. BRANCH : College of Technology, Manchester, "Efficiency of the Kaskade Distillation Column," F. H. Garner, S. R. M. Ellis and A. J. Hugill, 3 p.m.

Tues., April 14th.—Geological Society, Burlington House, Piccadilly, London, W.1, "The Fractionation of Liquid Air," G. G. Haselden, 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., April 14th.—STRUCTURAL AND BUILDING MEETING : Great George Street, Westminster, London, S.W.1, "The Design of a Reinforced Concrete Factory at Brynmawr, South Wales," O. N. Arup and R. S. Jenkins, 5.30 p.m.

Thurs., April 16th.—WORKS CONSTRUCTION AND RAILWAY ENGINEERING DIVISIONS : Great George Street, Westminster, London, S.W.1, Lecture and Film, "The Reconstruction of French Railways," M. Miot, 5.30 p.m.

Tues., April 21st.—ORDINARY MEETING : Great George Street, Westminster, London, S.W.1, "The Preservation of Timber," N. A. Richardson, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., April 13th.—RADIO SECTION : Savoy Place, London, W.C.2, Discussion on "The Relative Merits of Broad-Band Transmission by Beam, Cable and Waveguide," opened by E. C. H. Organ, 5.30 p.m.

Tues., April 14th.—MEASUREMENTS SECTION : Savoy Place, London, W.C.2, "Digital Computers at Manchester University," T. Kilburn, G. C. Tootill, D. B. G. Edwards and R. W. Pollard, "The Construction and Operation of the Manchester University Computer," B. W. Pollard and K. Lonsdale, "Universal High-Speed Digital Computers : A Decimal Storage System," T. Kilburn and G. Ord ; "Recent Advances in Cathode-Ray Tube Storage," F. C. Williams, T. Kilburn, G. N. W. Litting, D. B. G. Edwards and G. R. Hoffman, 5.30 p.m.——N. MIDLAND CENTRE : British Electricity Authority, 1, Whitehall Road, Leeds, 1, "Inherent Current Voltage and Speed Control in Dynamo Electric Machinery," J. C. Macfarlane, J. W. Macfarlane and W. T. Macfarlane, 6.30 p.m.

Thurs., April 16th.—UTILIZATION SECTION : Savoy Place, London, W.C.2, "The Technique and Development of Automatic Winding in Mine Shafts," B. L. Metcalf and G. Cottle, 5.30 p.m.

Mon., April 20th.—EDUCATION DISCUSSION CIRCLE : Savoy Place, London, W.C.2, Discussion on "Laboratory Experiments on Protective Gear," opened by H. P. Young, 6 p.m.

Tues., April 21st.—S.W. SCOTLAND SUB-CENTRE : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "The Stability of Oil in Transformers," P. W. L. Gosling and L. H. Welch ; "Inhibited Transformer Oil," W. R. Stoker and C. N. Thompson, 7 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., April 15th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, "Running Tests of a 500 h.p. Diesel Mechanical Locomotive," B. Reed, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, April 10th.—GENERAL MEETING ARRANGED IN CONJUNCTION WITH THE EDUCATION GROUP : Storey's Gate, St. James's Park, London, S.W.1, "The Athlone Fellowship Scheme for the Practical Training in Industry of Canadian Engineering Graduates in Great Britain," W. Abbott, 5.30 p.m.

Wed., April 15th.—WESTERN BRANCH GRADUATES' SECTION : Grand Hotel, Bristol, "Engineering Application of Probability and Statistical Methods," S. M. Taylor, 7 p.m.

Sat., April 18th.—N.W. BRANCH, GRADUATES' SECTION : Engineers' Club, Albert Square, Manchester, Annual General Meeting, "Thermal Insulation of Industrial Plants," A. G. Chdolansky, 2.30 p.m.

Fri., April 17th.—GENERAL MEETING : Storey's Gate, St. James's Park, London, S.W.1, James Clayton Lecture, "Materials Handling," J. R. Bright, 5.30 p.m.

INSTITUTION OF MINING AND METALLURGY

Thurs., April 16th.—Geological Society, Burlington House, Piccadilly, London, W.1, "Frothing Characteristics of Creosylic Acids in Flotation," Professor Shiou-Chuan Sun, and "A Review of American Progress in Geo-Chemical Prospecting, and Recommendations for Future British Work in this Field," J. S. Webb, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, April 10th.—W. WALES SECTION : Central Library, Alexandra Road, Swansea, "Advanced Science and the Production Engineer," Llewellyn Jones, 7.30 p.m.

Tues., April 14th.—DUNDEE SECTION : Queen's Hotel, Dundee, "National Standardisation and Productivity," E. L. Diamond, 7.30 p.m.

Wed., April 15th.—BIRMINGHAM SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, "The Contribution of Human Skills to Increased Productivity," W. D. Seymour, 7 p.m.——CORNWALL SECTION : Cornwall Technical College, Treverson Park, Poole, "The Application of Induction Heating," S. R. Tomes, 7.15 p.m.——S. ESSEX SUB-SECTION : Mid-Essex Technical College, Chelmsford, "Costing as an Aid to Management," H. H. Norcross, 7.30 p.m.

Thurs., April 16th.—SOUTHERN SECTION : Polygon Hotel, Southampton, "Engineering Problems of Aircraft Operation," B. S. Shenstone, 7 p.m.

INSTITUTION OF SANITARY ENGINEERS

Tues., April 14th.—Caxton Hall, Westminster, London, S.W.1, "Cathodic Protection of Buried and Submerged Pipe-Lines," K. A. Spencer, 6 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day April 10th.—WESTERN COUNTIES BRANCH : Geology Lecture Theatre, The University, Bristol, Annual General Meeting, 6 p.m.

Tues., April 14th.—MIDLAND COUNTIES BRANCH : Welbeck Hotel, Nottingham, "Some Notes on Designing to B.S. 449," V. H. Lawton, 7 p.m.——SCOTTISH BRANCH : Ca'doro Restaurant, Glasgow, Annual General Meeting, 6 p.m.——WALES AND MONMOUTHSHIRE BRANCH : S. Wales Institute of Engineers, Park Place, Cardiff, "Recent Developments in Timber Structures," J. R. M. Poole, 6.30 p.m.

Thurs., April 16th.—11, Upper Belgrave Street, London, S.W.1, "Economy in the Use of Structural Materials," G. A. Gardner, R. Morton and R. Creasy, 6 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Tues., April 14th.—Royal Society of Tropical Medicine and Hygiene, 26, Portland Place, London, W.1, Annual General Meeting, Films, "Basic Principles of Lubrication," "Krillium," 7 p.m.–8.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, April 10th.—ORDINARY MEETING : Townsend House, Greycoat Place, London, S.W.1, "Developments in the Design of the Steam Locomotive," D. M. Hunter, 7 p.m.

Mon., April 13th.—SHEFFIELD AND DISTRICT SECTION : Livesey Clegg House, Sheffield, Film Evening, 7.30 p.m.

Fri., April 17th.—INFORMAL MEETING : Townsend House, Greycoat Place, London, S.W.1, "Graphic Reproduction," J. F. Trusty, 7 p.m.

NEWCOMEN SOCIETY

Wed., April 15th.—Science Museum, South Kensington, London, S.W.7, "A Warwickshire Windmill, and Some Notes on Early Millwrighting," "Notes on the Windmill Drawings in Smeaton's Designs," "Lincolnshire Windmills, Part I—Post Mills," Rex Wailes, 5.30 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., April 17th.—Mining Institute, Newcastle upon Tyne, "The Development of Modern Naval Machinery and the Consequent Maintenance Problem," A. Funge Smith, 6.15 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., April 13th.—42, Great George Street, Westminster, London, S.W.1, "Modern Housing Construction," R. W. Wates, 5.30 p.m.

WOMEN'S ENGINEERING SOCIETY

Wed., April 15th.—MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, "The Mass Spectrometer," Winifred Hall, 6.30 p.m.

Mon., April 20th.—LONDON BRANCH : 35, Grosvenor Place, London, S.W.1, "Design of Water-Tube Boilers," Miss J. E. Gardiner, 6.30 p.m.